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New York, December, 1909.

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The Proposed New Chemists' Club Building.

The Chemists' Club, of New York, has become the professional home of all chemists of this country. It has acted as the host of all the different chemical societies. It has created a true chemical democracy. The spirit which it has created is reflected in the way in which progress is being made with the project of erecting a fine large new home for the Club. At the last smoker (a Harvard night, at which Prof. Theodore W. Richards was elected an honorary member of the Club) it was announced that $210,000 had so far been subscribed for the building. To bring the project to a successful end must be the ambition of every American chemist for the Chemists' Club does not stand for New York alone; it represents the united democracy of American chemists.

Standardization of Dry Cells.

The dry-cell industry in this country has now an annual output of some 40,000,000 cells and is still continually growing. But the general lack of exact knowledge about the dry cell is appalling, while the usual methods of rating dry cells reminds one at best of kindergarten methods for making electricity easy. It is certainly high time that a logical method for rating dry cells should be adopted. As a result of the two papers by Mr. Loveridge and by Professor Burgess and Mr. Hambuechen, the American Electrochemical Society has stepped in here by appointing a committee to standardize methods for rating and testing dry cells. This is an important undertaking. It is evident that the present usual method of rating cells by dimensions or by the short-circuit current must be replaced by a method of rating by energy output. But such a method requires an exact definition of the conditions under which the cell is to be tested. It would be strictly logical to change these conditions of testing according to the purpose for which the cell is to be used. However, this would result in several different ratings for the same cell, according to the different purposes for which it can be used, and this could easily cause confusion. It might be preferable to compromise on one all-around test for practical reasons. The work of the committee will not be exactly easy, but it must be done.

An Electrochemical Load for Central Stations.

More than once have we referred in these columns to the possibilities of using the power of central stations at times of low load for electrochemical and electrometallurgical purposes. There is something mutually attractive in such a scheme for central-station men on one hand and electrochemists on the other hand. The latter want cheaper power and the former a better load factor. With respect to electrolytic processes the objection has often been raised that it would not do to run them intermittently or semi-intermittently, and that for best operation absolute unifomity of the load is necessary. But Mr. Spalding's paper, published in this issue (page 526), shows that

a sound compromise is possible and practical. His account of what is actual practice in a successful electrolytic copper refinery, in combining electrical energy generated from the waste heat of furnaces with energy brought from a power company, should prove suggestive reading; and it should be kept in mind that in this case the refinery buys part of the needed energy from the power company, although the price charged by the latter can hardly be called liberal.

Design of Electric Furnace Electrodes.

The rapid progress of the use of electric furnaces in commercial operation has necessarily resulted in great advances in design. This fact is well illustrated by the numerous articles relating to electrode design published during the past year in our columns, especially the articles of Mr. Hansen and Mr. Hering. An account of a discussion of the problem of electrode losses in several papers at the recent meeting of the American Electrochemical Society will be found in the convention report in this issue. In view of the mass of literature now in existence on this special subject, it seems worth while to state in the simplest non-mathematical language and as briefly as possible the fundamental principles. Let us assume that we have an electrode of given dimensions and keep its one end at a certain high temperature (furnace temperature) and keep the other end cool (for instance, by a water jacket). If no electric current passes through the electrode, we have simple heat conduction from the hot end to the cold end due to temperature difference. When we begin to pass a current through the electrode we have a superposition of two phenomena: the simple heat conduction as before, due to the temperature difference at both ends, and the generation of heat from electrical energy within the electrode. The latter, the total Joulean heat generated within the electrode, tends to flow off impartially to both ends, one-half to one side and one-half to the other side. Hence, the heat loss from the cold end of the electrode into the water jacket is not only the heat conducted away due to the temperature difference at the two ends, but is increased by one-half the Joulean heat. This sum is termed the "electrode loss." At the hot end the heat which flows into the electrode from the furnace on account of the temperature difference between the two ends, is diminished by half the Joulean heat loss. If we increase the current steadily (always maintaining the temperatures constant at the two ends), the Joulean heat loss increases; and when it has grown to such a value that half the Joulean heat just equals the heat conduction loss due to temperature difference, then there will be temperature equilibrium at the hot electrode end. The two heat quantities—one due to temperature difference at the two ends and the other due to Joulean heat—just balance each other. No heat will flow through the hot electrode end in either direction. If we increase the current still further, the half of the Joulean heat flowing out from the hot end of the electrode into the furnace will actually overbalance the heat which would flow in the opposite direction due to the temperature difference between the two ends. In this case the temperature will be a maximum at some point within the electrode and from this point the temperature will decrease to both sides. For practical operation it seems generally advisable to make the conditions so that no heat flows in either direction through the hot electrode end. In this case the simple heat conduction, due to the temperature difference at both ends, equals one-half the Joulean heat, and the "electrode loss" (the heat given off to the water jacket) equals just the total Joulean heat.

* * *

For the sake of simplicity we have so far assumed that the temperatures at the two ends are maintained constant while the current is gradually increased in an electrode of given dimensions. In practice the problem is different, because the furnace temperature depends on the current. What is given are the current and the two temperatures at the two ends. What we want to find are the dimensions of the electrode, its length and cross-section. We want to select these so that half the Joulean heat equals the heat loss due to temperature difference between the ends. Now, it is evident that the Joulean heat loss is greater the longer the electrode and the less its cross-section; it increases with increasing ratio of length to cross-section. On the other hand, the heat conducted from the hot end to the cold on account of temperature difference between the two ends is smaller, the longer the electrode and the less its cross-section; it decreases with the increasing ratio of length to cross-section. The total electrode loss depends on the ratio of length to cross-section, and the preferable condition, in which the heat loss due to temperature difference equals half the Joulean heat, is fulfilled if the ratio of length to cross-section of the electrode has a certain value. This value depends on the electrode material, the current, and the temperatures at the two ends. As analysis shows, this value is inversely proportional to the current. Therefore, instead of saying that for the best conditions of operation the ratio of length to cross-section is fixed by current, electrode material, and the two temperatures, we can just as well say that the product of length of electrode and of current density in the electrode is fixed by the electrode material and the temperatures at the two ends.

* * *

Current density plays, however, another important part in furnace operation. Mr. Hansen states that as a result of his experience he has found that carbon electrodes cannot be run with a current density above a certain value nor graphite electrodes with a current density above another certain value, without corroding badly the end walls of the furnace. This statement can be slightly generalized by stating that the current density should not be so high that undesired decomposition of the walls or of the furnace charge near the electrode end are produced. We know of at least two cases in practice in which by forcing the current density too high, quite considerable losses resulted from evaporation from the charge near the electrode end. Clearly this is a matter of temperature, and the temperature depends on the number of watts per cubic centimeter, which are determined by the current density. The current density, therefore, plays an important rôle in this respect, but this cannot be easily formulated in general rules, since the permissible temperature depends on the conditions of every special case, not only on the electrode material, but on the nature of the material of the walls and of the charge under treatment.

Electric Smelting of Iron Ore.

There can be no doubt that in not too far a future there will be a number of commercial electric furnaces operating for the reduction of iron ore in specially favored localities—favored by

cheap electric power and a good market, but unfavorable to blast-furnace operation. The only doubtful matter is the details of the design of the electric furnace for iron-ore reduction. As our readers know, the problem has been taken up on a practical scale, both in California and Sweden. In both localities the work is progressing and the outlook is stated to be promising. But finality has not been reached by any means. There seems to have been a hitch in carrying through the project of starting a really commercial smelting plant using the Swedish electric shaft furnace. Nevertheless, progress has been made toward commercial operation, as will be seen from the following report which has just reached us and which may be considered as authoritative: "In order to carry out a fully impartial and exhaustive test of the electric shaft furnace for pig-iron production constructed by the A. B. Elektrometall in Sweden, the Jernkontoret—a representative organization of all the Swedish iron and steel works—will take over the plant to be erected in Trollhattan. One furnace of 2500 hp capacity will shortly be built for this purpose and, in case of success, the Jernkontoret will acquire the Swedish patent rights of the inventors, paying a royalty of 1.25 kr (33.5 cents) per metric ton of iron produced by its members in the furnace. A sum of 250,000 kr. ($67,000) has been voted for the experiments which will extend over a period of two years." Qui vivra verra.

* * *

In this connection the American Electrochemical Society paper of Mr. Edward R. Taylor, which is published elsewhere in this issue, is interesting. The design of his electric iron-ore reduction furnace has many points of similarity with his carbon-bisulphide furnace, which is commercially successful on a large scale. But the chief point of interest is the scheme of charging the ore and the fuel separately into the furnace. Since doubts have been raised in the discussion of Mr. Taylor's paper as to the advisability or practicability of such a scheme, it seems worth while to discuss it somewhat more in detail, as it has to do with one of the most fundamental points of the whole problem. There can be no doubt that under the special conditions, under which electric iron smelting can be commercially successful, it is important to utilize to the utmost within the furnace itself the energy value of the coke used as reducing agent. The ordinary blast furnace is a large gas producer on account of the carbon monoxide contained in the gas given off. This gas is utilized outside of the furnace, most efficiently in gas engines to produce electric power. With electric iron smelting, for which the availability of cheap electric power is presupposed, such a procedure is hardly attractive. The object must be to transform, if possible, all the carbon into carbon dioxide within the furnace itself. The question is, therefore: why is this impossible in the blast furnace and under what conditions would it be possible in the electric furnace?

* * *

The essential point is that the combustion of carbon to CO_2, either in the electric furnace or in the blast furnace, cannot be complete, as long as the ore and carbon are charged together. In this case the amount of CO_2 formed (in comparison with C and CO, with which it is in contact) is limited, since it cannot be more than the proportion corresponding to the equilibrium between the different substances which are in contact with each other. If we assume, for the sake of argument, that it was possible to change all C to CO_2 in some way, then the reverse reaction would immediately take place, by which the CO_2 would be reduced to CO by the elementary carbon with which it is in contact. For this reason the blast furnace and any furnace in which the charge is introduced mixed together, is necessarily a gas producer yielding a combustible gas. It is entirely different—at least in theory—if the iron ore and the carbon are introduced separately into the furnace and are mixed together only in or near the smelting zinc. In this case a mixture of carbon monoxide and carbon dioxide will be formed, and when this gas mixture is made to expand through the charge of iron ore (which is not mixed with carbon), there will be further reduction of iron oxide by the carbon monoxide which is thereby changed to carbon dioxide. Even so, when the gas mixture has risen to a certain height, it will be so dilute that no further reduction takes place. But then it is still possible to blow at this point air from the outside into the gas mixture and burn the carbon monoxide within the furnace itself so as to preheat the charge. In this way and only under the condition of the absence of elementary carbon at this point is it possible to utilize the whole energy value of the carbon within the furnace itself.

* * *

This scheme, in its fundamental principle, is not new. It was the underlying idea of Mr. Héroult's iron-ore reduction furnace, described in our Volume IV, page 152. He recognized clearly that the higher the point where the air is finally blown in for the combustion of the carbon monoxide, the greater will be the utilization of the reducing power of the carbon monoxide, although such reducing power is a diminishing quantity. The lower the point of injection of air, the greater is the heat developed and the less the reduction of ore. But the method of charging the carbon and ore separately into the furnace is different with Dr. Héroult and Mr. Taylor. In Dr. Héroult's original scheme a hollow central electrode was used through which the carbon was fed down. Yet electrodes offer enough troubles, anyway, leaving aside specially constructed hollow electrodes. Mr. Taylor's method seems far more feasible and practical. When in the historic trials at Sault Ste. Marie with the Héroult shaft furnace, under Dr. Haanel's direction, a single experiment was made blowing air into the charge near the top of the shaft, trouble was experienced due to the charge sticking on account of the heat developed. Whether any similar difficulty would be experienced with Mr. Taylor's furnace is an open question, since the design is quite different.

* * *

Another criticism made in the discussion of Mr. Taylor's paper by Mr. Hansen brings out clearly the great practical advantage of intimately mixing together the different substances which are to act on each other. But the conditions of Mr. Hansen's ferrosilicon furnace appear to be different from those in the Taylor furnace, where provision is made (by means of screws) to bring about an intimate mixture of ore and carbon near the smelting zone. How far this is possible can hardly be guessed. How the screws and other details of the design would work can also be found out by experience only. It is a pity that Mr. Taylor does not seem to have made any actual trials of his furnace on a large scale. But, in any case, his furnace construction is interesting in so many ways that it should be tried. After all, the proof of a furnace is in the running.

Nichols Medal.

At the meeting of the New York Section of the American Chemical Society, held in the Chemists' Club on Nov. 5, the Nichols medal was awarded to Dr. Leo H. Baekeland for his papers on "the synthesis, constitution and industrial application of bakelite" and "soluble and fusible resinous condensation products of formaldehyde and phenol." We heartily join Dr. Baekeland's many friends in extending to him our sincere congratulations on the honor which has been conferred on him and which is so well deserved.

Chemists' Club Building.

The Percolator is the title of a new monthly bulletin of the Chemists' Club. The issue of Nov. 15 contains some interesting information concerning the proposed new Chemists' Club Building.

The incorporation of the Chemists Building Company is now complete. At a meeting held on Nov. 12 the following directors were chosen: Morris Loeb, president; Charles F. Chandler, vice-president; Albert Plaut, treasurer; W. H. Nichols, Jr., secretary; Leo H. Baekeland.

The architects are busy with the plans of the building, and it is hoped that estimates can be obtained shortly. Subscriptions now amount to $165,550, but the finance committee are still lacking about $30,000 before the directors will be warranted in declaring the plan operative, and it is the duty of all those interested in the project to lighten the arduous labors of this committee.

While the Chemists' Club will profit largely by the erection of this building, the fact cannot be emphasized too strongly that all the chemists of the United States will be benefited to an equal degree, not merely those residing in New York. Nonresidents will find it a very suitable stopping place during their occasional visits to the city, and particularly convenient by reason of the library and other professional conveniences which this building will contain.

The Chemists' Club Building Company is independent of any management from the Chemists' Club. Subscribers to the stock will have a permanent equity in New York real estate, and while their dividends are limited to 3 per cent, so long as the Chemists' Club is in prosperous existence they are to be shareholders in a well-constructed office building, in the best possible business location, should the club, for any reason, fail to fulfill its present prospects.

This is a very different plan from the ordinary scheme, whereby a club erects its own building on a very slender margin and obtains additional funds by selling bonds to its own membership which can only be liquidated through expensive foreclosure proceedings. Anybody intending to subscribe should communicate with the chairman of the subscription committee, Mr. Maximilian Toch, 320 Fifth Avenue, New York City.

American Institute of Chemical Engineers.

The second annual meeting of the American Institute of Chemical Engineers will be held in Philadelphia from Dec. 8 to 11. The headquarters will be the Hotel Walton, where the first meeting will be held on Wednesday, Dec. 8, at 10 a. m. After a business session, the following two papers will be presented and discussed:

"Natural-Draft Gas Producers and Gas Furnaces," by Ernest Schmatolla. (Discussion by O. K. Zwingenberger and G. E. Barton.)

"The Commercial Extraction of Grease and Oils," by William M. Booth. (Discussion by Frederick Dannerth, Louis Olney and Samuel P. Sadtler.)

For the afternoon various visits have been arranged, either to the chemical, engineering and physical laboratories of the University of Pennsylvania, or to the Commercial Museum of Philadelphia, or to the works of Harrison Brothers & Company at Gray's Ferry Road.

In the evening at 7:30 the address of the retiring president, Dr. S. P. Sadtler, will be delivered, and will be followed by an address of Prof. Charles E. Munroe on the chemical industries of America.

On Thursday at 9:30 a. m. the members of the Institute and their guests will assemble at Race Street Wharf, on the Delaware, and be conveyed by the city boat *S. H. Ashbridge* to the Torresdale filtration plant; returning stop at Tacony to visit the wool degreasing plant of Erben, Harding & Company. Luncheon will be taken at the works of the Welsbach Light Company as the guests of the company. The party will then be conducted through the works of the Welsbach Light Company. In the afternoon the party will return by boat to Kaighn's Point, and a visit will be paid to the by-product coke oven plant of the Camden Coke Company.

In the evening a subscription dinner will be held at the Hotel Walton (price, $3).

On Friday morning the new officers of the society will be installed and a business meeting will be held. This will be followed by the reading and discussion of papers:

"Multiple-Effect Distillation," by F. J. Wood.

"The Advantages of the Multiple-Effect Distillation of Glycerine and Other Products," by A. C. Langmuir. (Discussion by S. S. Sadtler and Charles L. Reese.)

"Reclaiming of Waste India Rubber," by S. P. Sharples. (Discussion by William M. Grosvenor.)

In the afternoon an excursion will be made to Trenton, where the potteries, the Hamilton Rubber Company and the linoleum works will be visited.

In a meeting in the evening the following papers will be read and discussed:

"Materials for Textile Chemical Machines," by Frederick Dannerth. (Discussion by Louis A. Olney and J. M. Matthews.)

"Electric Smelting of Iron Ore," by E. R. Taylor.

"Chemical Composition of Illinois Coal," by A. Bement.

"Heat Efficiency of Smokeless Combustion and Heat Absorbing Capacity of Boilers," by A. Bement.

"Hydrogen Peroxide Solutions," by L. W. Andrews.

On Saturday, Dec. 11, an excursion will be made to the cement plants at Allentown, Pa.

Dr. Samuel P. Sadtler is the president of the Institute and Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y., is the secretary.

The Iron and Steel Market.

Actual new buying of finished steel products has been relatively light in the past month, partly because buyers are well covered, but largely also because the mills are pursuing a very conservative course and are avoiding sales far into the future unless the buyer absolutely requires the protection. Specifying on old contracts has been heavy all along the line, although the volume has decreased somewhat on account of contracts expiring Dec. 31 being already so well specified against.

The market does not present altogether as enthusiastic a tone as it did two months ago, but the position seems to be eminently satisfactory to producers, as the chief fear they have expressed has been of a runaway market.

Production records are being broken right along at individual plants and in individual trains of rolls, and the marvel is that in many cases the equipment has not been changed since previous records were made, generally in 1907.

The rate of pig iron production in November for the country at large passed 31,000,000 tons a year, compared with the maximum rate attained in 1907, 28,000,000 tons. The merchant furnaces have made but a very slight gain over their previous record, so that substantially the whole gain has been by the steelworks furnaces, indicating a large percentage increase. Scrap.

however, has been unprecedentedly scarce, commanding substantially as good prices as pig iron, and the make of open-hearth steel has probably not increased altogether as much as the make of basic pig iron.

Heavy melting steel delivered in the Pittsburgh district and in eastern Pennsylvania has been maintaining a level of $18 or higher, which is a high price compared with finished steel prices, while it is far above the cost of making pig iron to interests possessed of their own ore. In consequence the duplex process is being more and more considered, and within a few years perhaps the majority of the large independent steel interests will be found using it, while it is understood that the matter is being canvassed even as regards the Gary plant of the United States Steel Corporation. The general proposition is reduced to round figures thus: If scrap costs $18 on a half-pig and half-scrap charge, and pig iron can be produced at $14, from owned raw materials, and it costs $2 to blow the metal, then 2 tons of steel can be produced from material costing $16 a ton, instead of 1 ton from material costing $14 for half a ton and $18 for the other half, so that output is doubled without an increase in the cost per ton. The figures used, of course, are only conventional.

Lake Superior Ores.

On account of several spells of particularly bad weather, the accident to the Poe Lock at the American Soo and some minor accidents, the Lake Superior ore trade will probably be disappointed in its expectation of breaking the 1907 record for a season's movement, that standing at a trifle over 42,000,000 tons. An announcement of Lake Superior ore prices for the season of 1910 is likely to be made in the first fortnight of December. Several propositions are understood to have been under consideration, one a straight advance of 50 cents a ton, which would balance the reduction made for the season of 1908; another an advance of 50 cents on non-Bessemer ores and an advance of 75 cents on Bessemer ores, and another a reduction in the base guarantee of iron content from 55 per cent to 52½ per cent on Bessemer ores and from 51½ per cent to 50 per cent on non-Bessemer ores. The suggestions are tentative, and in case the base guarantee were lowered, the advance in prices per ton would not be as large as otherwise.

Coke.

The deadlock in Connellsville furnace coke for 1910 continues. About half the tonnage usually subject to contract for annual or semiannual periods was closed some time ago, chiefly in September, the price being run up to $2.90 per net ton at ovens. Contracts for the present half year had been made last May at $1.60 to $1.70, so that the advance was quite spectacular. There remains furnace consumption yet to be covered amounting to about 200,000 tons of coke per month, and it is possible that the buyers may wait until after the turn of the year before contracting, possibly buying prompt coke for a time as they evidently feel that developments are likely to be in their favor. Production in the Connellsville and lower Connellsville region has been running since the middle of October at a trifle above 450,000 tons weekly, the best weekly output attained in 1907 having just fallen short of 430,000 tons. There has been an increase of about 6000 in the number of ovens in two years, from a trifle over 33,000 to a trifle over 39,000. Some of the ovens are in connection with worked-out coal seams, as was also the case two years ago, the proportion actually available having undergone no important change. It is believed that with an adequate labor supply the region can work up to a weekly output in excess of 500,000 tons, which should be ample to cover prospective requirements for next year. The labor supply has been improving in numbers and efficiency, and a further improvement is expected after Jan. 1, as a general wage advance is in prospect for that date.

Pig Iron.

On the whole, the pig-iron markets have presented a strong tone, but have scored no important advances, and at some points weakness has appeared. Southern iron, which had been firm at $15, Birmingham, became available in October at $14.50, if for prompt shipment, while a valley furnace did some cutting in foundry iron. One or two lots of basic iron appeared in the East at cut prices. The advance in pig iron seems to have been arrested, but the month's developments are rather characteristic of a normal trading market than indicative of any declining tendency. Prices are quotable at valley furnaces (90 cents higher delivered, Pittsburgh), as follows: Bessemer, $19 to $19.10; basic, $17.25 to $17.50; No. 2 foundry, $17.25 to $17.50; gray forge, $16.25 to $16.50; malleable, $17.50 to $17.75, the range in prices representing chiefly difference in delivery, next year's deliveries being uniformly higher than prompt delivery.

Steel.

The Carnegie Steel Company has put its No. 2 mill at the Edgar Thomson steel works on billets. This is the original rail mill, and years ago it was regularly operated as an interchangeable mill, operating alternately on rails and billets, but for some time past it has not made billets. Part of the output goes to the No. 3 mill, the new light rail mill, electrically driven. The Nos. 1 and 3 mills are making 6000 tons to 8000 tons of rails a week, being gaited. The attached blast furnaces and converters are running full, surplus ingots and billets going to allied plants. Monday, Nov. 15, the company started its Bessemer converters at Homestead, which have been idle since 1907, the steel going chiefly to the structural mills. The long idleness of this Bessemer department, and the abandonment two years ago of the Bessemer department at the Duquesne Steel Works, are suggestive of the changed status of the Bessemer converter as compared with the open-hearth steel furnace. Engineers practically refuse to take Bessemer steel plates, and the tonnage of Bessemer structural shapes acceptable is restricted. Bessemer steel still has usually the call for tin plates, sheets, wire products and pipe, while in rails it has a contest.

Unfinished steel is scarce, and market transactions are limited. Billets are quotable nominally at $27, Pittsburgh, and sheet bars at $28 to $30, the latter being for next year's delivery. Rods are about $32.50, Pittsburgh.

Finished Materials.

Steel bars are quoted at $1.50 and plates and shapes at $1.60 by all the independent producers, but the Steel Corporation subsidiaries have been selling in a limited way at a dollar a ton less to old customers and for definite requirements, the action being due to an effort to forestall a too rapid advance in prices.

On Nov. 12 the American Sheet & Tin Plate Company announced the following price advances:

Tin plates, $3.50 to $3.60 for 100-lb. cokes.

Blue annealed sheets, $1.70 to $1.75 for No. 10 gage.

Black sheets, $2.40 to $2.50 for No. 28 gage.

Galvanized sheets, $3.35 to $3.50 for No. 28 gage.

Painted corrugated roofing, $1.60 to $1.70 per square for No. 28 gage, 2½-in. corrugations.

Galvanized corrugated roofing, $2.85 to $3 per square for No. 28 gage, 2½-in. corrugations.

The above advances were promptly followed by the independents, except that in blue annealed the independents advanced to $1.80 as they are able to make fairly prompt deliveries, the leading interest promising deliveries on this material only in about three months.

Other prices stand as follows, f.o.b. Pittsburgh, except where otherwise noted:

Steel bars, $1.45 to $1.50, base.

Iron bars, $1.70 to $1.75, base, f.o.b. Pittsburgh mill; $1.55 to $1.60, Chicago; $1.60 to $1.70, Philadelphia.

Plates, $1.55 to $1.60.

Shapes, $1.55 to $1.60.

Standard rails, $28 for Bessemer and $30 for open-hearth, f.o.b. mill, except Colorado; light rails, 25 lb. to 45 lb., $27 to $28.

Merchant pipe, extreme discount, 80 and 5 off list for steel; 74 and 5 off for iron.

Plain wire, $1.60; wire nails, $1.80, base; painted barb wire, $1.80; galvanized barb wire, $2.10; foregoing prices to jobbers for specifications within 30 to 60 days; wire to manufacturers, delivery over first half, $1.70, base.

Testing of Electrical Instruments at the Bureau of Standards.

We have received from the Bureau of Standards, in Washington, D. C., Bureau Circular No. 20 on the "Testing of Electrical Measuring Instruments."

The first 22 pages are an excellent, concise review of the principles, applications and limitations of various electrical instruments. This review is worth careful reading by every user of electrical instruments. Direct-current and alternating-current instruments are covered, also integrating instruments, recording instruments, accessory apparatus, including instrument transformers, sources of error, reliability of electrical instruments and apparatus for checking instruments.

This part of the bulletin is a very useful, concise and clear exposition of the fundamental principles of construction and application of the various commercial electrical measuring instruments and deserves the widest distribution among users of instruments.

The second part of the bulletin contains the regulations for instrument tests at the Bureau of Standards, with general instructions, schedule of fees, and notes on special tests and measurements.

The circular will be sent to anyone upon request. All communications should be addressed to the "Bureau of Standards, Washington, D. C."

CORRESPONDENCE.

Drying.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—I have read with great interest the very thorough technical article upon drying, in your November number, by John Jermain Porter. This article shows a great amount of care and knowledge in its preparation. I wish to take exceptions, however, to some of his conclusions, which, I believe, are due to wrong premises.

The article states that the maximum efficiency is obtained when the theoretical amount of air is used in consuming the fuel. Other things being equal, this is undoubtedly true; but in burning ordinary coal with the theoretical amount of air, a temperature of 4500° Fahr. to 5000° Fahr. would be obtained, so that even were this possible, firebrick, cast iron and steel, used in the construction of a dryer, would be melted down like wax. The only practical way to burn fuel for drying purposes is to admit about three times the theoretical quantity of air so that the temperatures do not exceed 1500° Fahr.

The article also states that "the presence of hydrogen in fuels decreases materially their value for drying purposes." This would undoubtedly be true if, as the article assumes, the drying should all be done by absorption of moisture by the air. As a matter of fact, the loss in heat, due to the formation of water by the combustion of hydrogen, is less than 17 per cent of the total heat generated, and as the amount of hydrogen in ordinary coal is about 5 per cent, the total loss of heat due to hydrogen in the coal, amounts to less than 1 per cent of the total calorific value of fuel, which is a neglectable quantity compared with other losses. The amount of moisture absorbed by the air is a very small proportion of the amount driven off in drying of inorganic substances. The temperature at which drying is done is considerably above 212°, so that most of the water passes off as steam or watery vapor and a very small proportion is absorbed by the air. Should we depend only upon absorptive power of the air, the capacities which could be obtained in drying would be exceedingly small.

The article states that "in a counter-current dryer the solid dried materials must pass out at a temperature approximating, or equal to, the temperature of the gases of combustion as they enter the dryer." This is only true when very small capacities are required, and where very high temperatures are desired. The writer has seen scores of counter-current dryers in which the temperature of the entering products of combustion was 1200° Fahr. or greater, while the dried material being delivered was not over 230°. Therefore, the contention of the article that the great loss of specific heat of the material made such a dryer more wasteful in fuel than the "parallel-current" dryer cannot be maintained. As the products of combustion pass through the cold material before going to the stack, the temperatures can be reduced to 100° Fahr. or less, so that a greater saving can be made in this way, more than counterbalancing the greater heat carried out by the dried material. With a "parallel-current" dryer, in which the material flows in the same direction as the products of combustion, the exhaust temperatures of the escaping gases and steam must be above 212° Fahr. or recondensation takes place and the drying material will be delivered wet.

The article speaks of the loss of heat by radiation merely in the formulas, but does not mention what this may possibly amount to. As a matter of fact, one of the greatest losses in drying material is due to this cause, and the writer has made tests where this radiation amounted to over 50 per cent of the calorific value of the fuel, and in any single-shell dryer, which the article assumes to be the only type, the loss in this way is never less than 35 per cent.

A well-known dryer is being made in which the loss of radiation is not over 7 per cent; the loss by the exhaust temperature of the air not over 8 per cent, and the loss by the specific heat of the dried material not over 5 per cent, so that a total efficiency of 80 per cent is obtained from the fuel, against about 46 per cent in the ordinary old style of single-shell machines.

NEW YORK CITY. W. B. RUGGLES,
President, Ruggles-Coles Engineering Company.

* * *

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In replying to Mr. Ruggles' letter criticising my article on direct-heat dryers, I wish to emphasize the fact that the paper was intended only as a theoretical study and necessarily involved some assumptions which will not hold true in practice.

Mr. Ruggles' first criticism is well taken from his standpoint, it being impracticable for several reasons to burn fuel with the theoretical quantity of air.

With regard to the second criticism, it is true that the quantity of hydrogen in coals is so small as to be unimportant, but this is not true of some of the gaseous fuels, for example, natural gas and water-gas. I might state in this connection that this paper is the outgrowth of calculations and experiments which were made to determine the relative value of coke and natural gas as fuels for a set of core ovens.

With regard to the third criticism, it is, of course, true that if a perfect heat interchange is not effected, the formula will not hold true. However, it is also true that if the waste gases are reduced to a temperature of 100° Fahr. the amount of water evaporated is limited by the amount which will saturate the gases at that temperature and it is difficult to see how this condition could be conducive to efficiency.

The fourth criticism is, I think, answered sufficiently by the statement that the paper was intended only as a theoretical study.

In conclusion, I wish to say that I regard Mr. Ruggles' comments as a valuable contribution to the literature on dryers, and I feel some satisfaction in having been the indirect cause of its production.

UNIVERSITY OF CINCINNATI. JOHN J. PORTER.

NEW YORK MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

It is a pleasure to report the great success attained at the sixteenth general meeting of the American Electrochemical Society, which was held in New York City on Oct. 28, 29 and 30.

Since 1906 the autumn meeting has always been held in New York, this arrangement having been found advisable four years ago for the following reasons: At that time many members thought that two general meetings a year were one too many, and it was proposed to hold only one annual meeting. As this would, however, have meant the publication of only one volume of *Transactions* a year instead of two, the usefulness of the society would have been very seriously impaired.

It was then decided to adopt a compromise plan—namely, to hold one large annual meeting each spring, at different places from year to year, and another meeting of secondary importance each autumn in New York City. It was thought that many members, not residing in or near New York, would anyhow come to New York for business reasons some time in autumn and could easily arrange the date of their visit so that they would attend the meeting of the society. Aside from this, the success of the New York meeting would be assured by the very large membership of the local section.

So far the plan has worked very well. Since 1906 the spring meetings have been held in Cornell University, Philadelphia, Albany-Troy-Schenectady, and Niagara Falls; they all were exceedingly enjoyable and immensely successful. On the other hand, the first New York autumn meeting, in 1906, represented a decided minimum point in the career of the society; it proved of even less interest than the most modest advocates of an annual New York autumn meeting had expected. Everything was changed, however, in the autumn of 1907, when the New York Section, at its request, took hold of the New York meeting and made it a full success. This was repeated in 1908, while a decided climax was reached in the most enjoyable meeting just closed. The original plan of making the New York meeting of secondary importance only had, however, now been completely lost sight of.

Of course, it was but natural that with a highly distinguished and energetic New Yorker, Dr. L. H. Baekeland, as president of the national society, New York should make a special effort this year. While all New York members contributed to the success, credit is principally due to Dr. Baekeland and to the indefatigable secretary of the New York Section, Mr. Alois von Isakovics, while the general arrangements, especially of the professional sessions, were, as ever, very well taken care of by the secretary of the society, Dr. J. W. Richards, of Lehigh University.

There were three professional sessions, detailed reports of which will be found below. The first session, on Thursday afternoon, was held in the lecture hall of the Chemists' Club, the two sessions of Saturday morning and afternoon at Earl Hall, Columbia University. All sessions were well attended.

Excursion to Bayonne.

The whole of Friday was devoted to an excursion to the principal chemical and metallurgical industries of Bayonne, N. J., where a party of more than 200 was taken by a special train of the Central Railroad of New Jersey. As the Mayor of Bayonne, Hon. Pierre P. Garven, explained in welcoming the party to the city at luncheon in one of the shore resorts, Bayonne is a rapidly growing industrial center with great commercial possibilities on account of its enormous waterfront on the Kill von Kuhl, and on New York Bay and Newark Bay.

PHOTOGRAPH TAKEN AT CONVENTION OF AMERICAN ELECTROCHEMICAL SOCIETY.

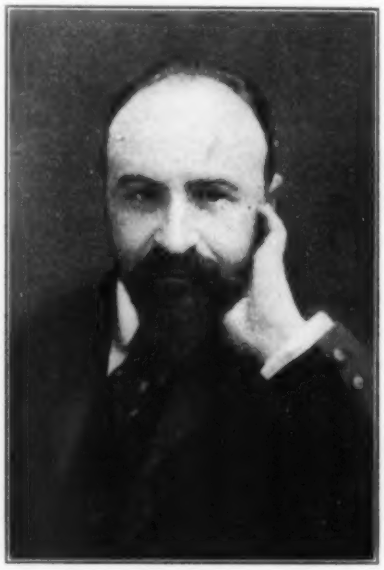
During the morning visits were paid to various plants on

Constable Hook. The acid works of the Standard Oil Company were first visited, where sulphuric acid is made from Spanish pyrite by the lead-chamber process. The fumes proved pretty irritating to some of the visitors and fresh air was a decided relief.

A small section of the National Sulphur Company was then visited (flowers of sulphur). The plant of the Pacific Coast Borax Company was next in line. The visitors were shown the methods of manufacture from the raw materials through the crystallizing tanks to the packing department, where lump and powdered "twenty-mule team" borax is put up in barrels. Boric acid is also made on a large scale.

The oil refineries of the Standard Oil Company afforded an excellent opportunity to study exhaustively modern methods of barrel making, both wood barrels and steel barrels or drums. Of the oil refinery proper the paraffine end of the works was shown, and samples of the final residue, after the petroleum processes have been completed, were inspected. This residue is about 95 per cent pure carbon. It is largely used in the manufacture of electrodes.

The last visit of the morning was made to the Gröndal briquetting plant at the works of the General Chemical Company.



L. H. BAEKELAND, PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY.

This is the first American installation of this process and has been in operation but a few months. It seems to be almost a duplicate of the one in Sweden, described and illustrated in our Vol. IV, page 510. Imported pyrite is used, the material briquetted being the residue after the sulphur is driven off in the manufacture of sulphuric acid. This residue is very rich in iron oxide, but in its disintegrated form it is unsuitable for the blast furnace. The briquets, however, can be satisfactorily used.

The first plant visited in the afternoon was that of the Babcock-Wilcox Boiler Company. This is a big and modern works and is still being added to. The administration building has been finished about a year ago, and contains the various engineering and draughting divisions, accounting, and, in fact, all the offices, as well as a finely equipped chemical laboratory and an interesting physical testing laboratory with apparatus for metallographical experiments.

In the plant were shown various boilers in course of construction, all of the standard Babcock & Wilcox water-tube type and built up of sectional units in the usual manner. The punching, shearing and drilling machines and the bending rolls for the cylindrical receivers were interesting. The automatic chain-grate stoker is also constructed here and could be seen in operation in the power plant. Power distribution is by electricity and compressed air for the riveters, hoists, etc. Five guides, were provided and definite routes carried out. The Babcock & Wilcox Company have another plant, of about the same size, in Ohio.

The last plants visited were those of the Electro-Dynamic Company, the Electric Launch Company, and the Industrial Oxygen Company, all three plants being near the Avenue A Station.

The specialty of the Electro-Dynamic Company is the manufacture of interpole motors in various sizes. All the processes of manufacture could be readily seen and some of the finished motors were on test. The "interpole motor" is exceedingly valuable in industrial works, where wide speed variations and heavy load fluctuations are the rule. The feature of the interpole motor is that under such severe conditions there will be no sparks at the commutator.

JOS. W. RICHARDS, SECRETARY AMERICAN ELECTROCHEMICAL SOCIETY.

The Electric Launch Company manufactures electric and gasoline launches of all designs and sizes. Several boats were in storage and some in course of construction.

At the plant of the Industrial Oxygen Company the processes of welding and cutting by means of the oxy-acetylene flame were demonstrated. An adjoining building contains a generating plant for the production of oxygen from oxygenite. An illustrated description of the interesting process of this company was given on page 431 of our Vol. VI.

The party returned then by their special train to New York.

Social Features.

In the evening of Friday a very enjoyable subscription dinner was held at the Hotel Cumberland. It was very well attended, with a large number of ladies in the party. Dr. Doremus was a forceful toastmaster, and speeches were made by President Dr. Leo H. Baekeland; by Professor Armstrong, of London, for the Faraday Society of Great Britain; by Dr. William H. Nichols, as the president-elect of the International Congress of Applied Chemistry, to be held in 1912 in this country; by Dr. William R. Whitney, as president of the American Chemical Society; by Dr. Morris Loeb, as president of the Chemists' Club; by Mr. Maximilian Toch, as chairman of the New York Section of the Society of Chemical Industry; by Dr. J. W. Richards, as secretary, and by Dr. H. W. Wiley, who made a great hit with his bachelor toast on the ladies.

ALOIS VON ISAKOVICS, SECRETARY NEW YORK SECTION, AMERICAN ELECTROCHEMICAL SOCIETY.

In the evening of Saturday the society was the guest of the Chemists' Club at a smoker in the clubhouse. Mr. Maximilian Toch showed some very interesting and amusing lantern slides made from photographs taken on the trip last summer of many American chemists to the International Congress in London.

Special mention should be made of the elaborate arrangements which the local ladies' committee, under the chairmanship of Mrs. L. H. Baekeland, had made for the entertainment of visiting ladies. The program included a reception and tea by invitation of Mrs. William H. Nichols at the Waldorf-Astoria on Thursday afternoon, an automobile ride and tea at the Claremont on Friday afternoon, and a theater party on Saturday.

Titanium Arc.

The first paper of the Thursday session was presented by Dr. William S. Weedon on an investigation carried out several years ago in the research laboratory of the General Electric Company. The work covered a large number of elements, compounds, and mixtures, with considerable variation in the method of preliminary treatment, as to their suitability for arc-lamp electrodes.

Among the substances that were tried there was none which gave as high an efficiency in candle-power per watt as material which contained the element titanium. The titanium arc is suitably formed between a titanium carbide cathode below a copper anode. The latter is inactive and does not waste appreciably. The titanium arc is a flame arc, and its efficiency increases with increase in current density and with increase in arc length.

At 3 amp, 103 volts and 1-in. arc length, it consumes only 0.228 watt per horizontal candle-power. The mean spherical candle-power at 2.87 amp, 95 volts (273 watts) is 535, and the mean hemispherical candle-power 737.6. On this basis the power consumption is 0.51 watt per mean spherical candle-power, and 0.37 watt per mean hemispherical candle-power; this corresponds to a yield of 1.96 mean spherical candle-power, or 2.70 mean hemispherical candle-power per watt. The electrical measurements were made at the arc terminals and the photometric measurements were made through a clear-glass globe of the usual thickness.

A study of the efficiency curves shows that titanium-carbide arcs are most satisfactorily operated on a constant-current circuit rather than on a low-voltage multiple circuit (with the necessarily short arc length). The author gave pictures of various flame arcs, and then described the preparation of the titanium-carbide electrodes. The lump material is coarsely powdered and then pulverized in a ball mill to a high degree of fineness. It is then worked in a roller mill with oil, glycerine or other suitable binder. After the material is thoroughly plastic it is extruded through a nozzle by means of a hydraulic press, the sticks being cut to suitable lengths.

After drying at ordinary temperatures, and then in a gas oven, the electrodes are fired at high temperature, preferably in an electric furnace of the carbon-tube type. After firing, the sticks should be firm and without cracks. If fired at too high a temperature they are liable to be brittle. The titanium-carbide arc may also be operated with alternating current under certain conditions.

The author finally referred to some experiments with the titanium suboxide arc, which can be operated only with direct current. The material used in these experiments was prepared in the electric furnace by the reduction of rutile. Its preparation is quite easy, since the melting point of the product is much lower than that of the carbide.

The character of the arc is almost identical with that of the carbide arc, but the light is much steadier. There are certain objections to this electrode, and among them are the tendency to form large troublesome deposits on the anode and the fairly rapid consumption of the suboxide stick.

The suboxide gives a light efficiency even better than the carbide. At 3.4 amp, 7/8 in. arc length and 100 volts 2100 candles (horizontal) are obtained. This gives a power consumption of 0.162 watt per horizontal candle-power, or a yield of 6.17 horizontal candle-power per watt. The distribution of the light is the same as with the carbide.

The heavy deposit on the anode is probably responsible for the fact that the difference in potential between the terminal is about 15 volts higher than is the case with the carbide at equal arc length and current.

In the discussion which followed, Dr. Whitney, the head of the research laboratory of the General Electric Company, explained that the paper had been finished in 1904, but that it had to be withheld from publication for commercial reasons. He referred to Tumlirz and Angstrom's figures for the electrical equivalent of light (Tumlirz's figure for the theoretically maximum efficiency is 0.188 watt per spherical hefner candle-power; Angstrom's figure is 0.102 watt per spherical hefner candle-power) and emphasized that with the titanium arc we are getting quite a deal nearer to theoretical maximum efficiency.

Professor Tucker thought from some experiments he had made that zirconium carbide might be found even more efficient than titanium carbide. But Dr. Weedon denied this. Dr. J. W. Richards said that the hypothesis had been offered that the heat set free in the oxidation of the electrode might account partly for the high efficiency, but he explained that from the calculations which he had made for this, it can only play a very small part. Mr. Shimer had been the first to isolate titanium carbide from steel. Dr. Weedon said that they had tried almost every carbide, but titanium carbide was the most efficient.

In such experiments the direction of the current may have an important effect on the results.

Boron.

Dr. E. Weintraub reported in a paper on an experimental research extending over several years and carried out at the Research Laboratory of the General Electric Company by the author with the assistance of E. Kraus and G. Weintraub. The properties of pure boron have so far been unknown, since the only material heretofore produced and alleged to be pure boron was in the form of an amorphous powder. The object of Dr. Weintraub's research was to produce pure boron in fused homogeneous form. (The investigation formed part of a research for elements suitable as a material for incandescent-lamp filaments.)

Reaction Between Boric Anhydrite and Magnesium.—This reaction was first studied since it was the starting point of Moissan's work. But Dr. Weintraub found that, however the conditions of the experiments might be changed, no homogeneous product was obtained. There was always a mixture of a dark product rich in magnesium and a brown product supposed to be boron.

The difference in composition and appearance between parts of the same fusion could only be accounted for by assuming differences in temperature. The brown material was found to prevail in the center of the mass, where the temperature is highest; the dark product, on the outside of the mass, where the temperature is lowest.

The brown substance, being apparently the product of the reaction at a higher temperature, two methods were recurred to for the purpose of production of a uniform brown fusion, namely, first, using a higher temperature furnace (an electric furnace, for instance), second, carrying out the reaction in an ordinary gas furnace on a large scale so that the temperature *inside of the mass* can attain a high value on account of the heat of the reaction itself.

Both methods led to the expected result. When a large crucible is charged with a kilogram or more of the reacting mixture the resulting fusion is of a uniform brown color throughout, except for a thin layer on the very outside, which could be easily removed.

After removal of this thin outside layer and the usual chemical treatment of the mass, the resulting powder was of a somewhat lighter color than the one obtained in following Moissan's descriptions, showing the absence of the dark magnesium boride, and analysis showed only 0.11 per cent magnesium instead of 3 per cent to 4 per cent, found when the reaction is carried out in the old way.

The preparation of a product practically free from magnesium has thus been achieved. Dr. Weintraub expected to find pure boron, but the analysis of the product gave only 83.2 per cent boron instead of 88 per cent to 90 per cent found in the product obtained in the old way. This was a surprising result.

The sum of all the elements determined (including boron nitride and traces of iron) was only in the neighborhood of 85 per cent and 15 per cent were unaccounted for. In the product obtained in the old way the sum differed from 100 by 4 per cent to 5 per cent. The question, therefore, arose what the impurity in the brown product, free from magnesium, might be. It could have been water, or admixed boric anhydride, or hydrogen introduced during the acid treatment (in which case the substance would be a complex boron hydride) or oxygen (in which case the substance would be a complex boron suboxide). The first three possibilities were disproved.

There remained only the fourth possibility, which was also proved to be correct directly by experiments. There was first some difficulty in finding a definite proof for the presence of oxygen. The method finally used for the proof of the existence of oxygen in the boron powder was based on the oxidizing action of potassium permanganate. The reducing action of boron on potassium permanganate was noticed by previous experimenters, notably by Moissan, but Dr. Weintraub found that with the boron obtained in the reaction between boric anhydride and magnesium, this reduction could be carried out in a quantitative way, so much so that a regular titration method could be developed.

A simple reasoning shows that if the impurity in the boron is oxygen in any form the consumption of permanganate would be less than that corresponding to the content in boron, since a part of the boron is in an oxidized condition beforehand. In the case of any other impurity the permanganate titration and boron determination should agree. The application of this method proved clearly that the brown substance, free from magnesium, contains oxygen. Dr. Weintraub calls it boronsuboxide for the sake of brevity.

He further studied the question whether the substance is homogeneous or a mixture of different compounds. In his first series of experiments he varied the conditions under which the substance was produced and investigated whether this changed the composition and properties

The result of the variation of temperature and ratio between boric anhydride and magnesium can be summarized in the following three statements:

1. Low temperature and low ratio of boric anhydride to magnesium favor the formation of boron containing large quantities of combined magnesium.

2. High temperature and a high ratio of boric anhydride to magnesium favor the formation of boron free from magnesium, but containing oxygen in form of suboxide.

3. If the excess of boric anhydride becomes too large it acts as a diluent and by lowering the reaction temperature leads to the formation of products containing both oxygen and magnesium.

By varying the conditions in such a way as to obtain products with only a small percentage of magnesium the composition of the suboxide was found not to vary much. In all cases a product is obtained containing 82 per cent to 85 per cent boron and 16 per cent to 14 per cent oxygen.

The author then, also, employed a second method in which the substance was submitted to different chemical treatments to see whether any separation of the substance into different parts would take place. Partial titration with permanganate was tried. The oxidation was carried out in different stages and the residue analyzed every time. But the residue had always approximately the same composition as originally. Assuming that a chemical individual is present, Dr. Weintraub concludes that the corresponding formula would be $B_{11}O_2$, or perhaps B_7O.

Dr. Weintraub then tried to re-fuse the brown substance thus obtained with a large excess of boric anhydride in order to produce pure boron, but he did not succeed. Other analagous experiments in which the reduction of boric anhydride by means of calcium, aluminium, etc. (instead of magnesium) was studied, gave even worse results.

Reduction of Boron Halides by Hydrogen.—The reaction between boron chloride and an excess of hydrogen—which has first looked little promising, proved to be the solution of the problem. In the first experiments it appeared, however, that when the reduced boron would come in contact with the hot walls of the furnace, for instance, with the walls of a silica tube at very high temperature, the silica would react with the boron. This is a general and interesting reaction between boron and oxides, like silica, alumina, magnesia, at very high temperatures. Around 2500° magnesium oxide is reduced by boron (while below 1600° boron anhydride is reduced by magnesium).

The solution, therefore, depended on the use of a very high temperature without bringing the produced boron in contact with the hot walls; this is accomplished by an arc discharge through a mixture of boron chloride and hydrogen.

The substances, boron chloride and hydrogen, are both gaseous at room temperature. The reaction products consist of one gaseous substance, hydrochloric gas, and one solid produce, namely, the desired element, boron.

The separation of this product would, therefore, offer no difficulties whatever.

The experiments soon revealed the advantages of the method. The blast of the arc removes the produced solid particles of boron out of the zone of the reaction by throwing them out onto the cold walls of the vessel or the cold electrodes. The reaction between boron chloride and hydrogen is a reversible one, as is shown by the fact that boron chloride can be produced by passing hydrochloric gas over boron heated to red heat. To insure a good yield in the reduction of boron chloride by hydrogen, it is, therefore, desirable to remove the boron as rapidly as possible from the very hot zone of the area, where the reduction takes place. The mechanical blast of the arc accomplishes this automatically. In this the reaction between boron chloride and hydrogen has the advantages over the reaction leading to nitric acid from nitrogen and oxygen.

A serious difficulty was the disintegration of carbon or graphite electrodes whereby the boron was contaminated. This difficulty was overcome by the use of copper electrodes, which do not disintegrate, while the affinity of copper to boron is exceedingly slight.

The method finally developed consisted accordingly in running one or more alternating-current arcs, fed by a high-potential transformer, between water or air-cooled copper electrodes, in a mixture of boron chloride with a large excess of hydrogen in a glass or copper vessel.

This boron is partly thrown off in the form of fine powder onto the walls of the vessel or onto the electrodes. It partly settles on the ends of the electrodes, where it grows in form of small rods. After a while the arc thus runs between two boron electrodes, and if the current of the arc is of proper value the rods melt down to boron beads, which eventually fall off, whereupon the same process repeats itself.

The product obtained consists, therefore, partly of powder and partly of fused lumps. The powder has to be washed with water to remove a small amount of boric anhydride, the formation of which is due to traces of air set free from the electrodes and the walls of the vessel. After the small amount of boric anhydride mixed with the powder is thus removed, the analysis gives 99 per cent to 99.5 per cent boron.

As neither copper nor hydrogen could be detected in the powder, the missing 0.5 per cent to 1 per cent may possibly be due to presence of a small amount of boron suboxide. It seems, in fact, impossible, unless very exceptional precautions are taken, to avoid oxygen in the gases, and possibly traces of boron oxychloride in the boron chloride used. As the permanganate titration does not give quantitatively with boron produced under these circumstances, the presence of a small amount of boron suboxide could not be proven.

The fused lumps of boron analyze from 99.8 per cent to 100.2 per cent. The difference from 100 is due to a trace of

silica which is introduced into the boron during the process of pulverization in the agate mortar and to the unavoidable analytical errors. Both the method of formation and the analysis proved the absolute purity of the fused lumps of boron.

The yield obtained is the greater the larger the excess of hydrogen used. Naturally, however, the amount of boron obtained per unit of time is the less. The yield is also the greater the larger the surface of contact between the arc and the gas. A number of arcs in the same vessel or in vessels mounted in series is, therefore, advantageously used. The best yield ever obtained by Dr. Weintraub in one vessel was 50 per cent of the theoretical. As a rule, however, 30 per cent can be considered satisfactory, and at the same time a reasonable speed of boron formation is obtained.

The boron chloride can be condensed out of the escaping gases and used over again.

The mixing of the gases can be carried out either by passing hydrogen over the surface of boron chloride placed in a vessel surrounded by a refrigerating mixture or by allowing boron chloride to drop into a vessel, kept a little above room temperature, through which hydrogen is passed.

In the arrangement of the arcing apparatus all the well-known modifications, such as use of a magnetic field, the introduction of gases through the electrodes themselves, etc., can be applied.

The boron powder obtained in the process can be purified and fused down by two different methods developed in the course of this investigation. These methods are very valuable in the treating of refractory materials and have become regular tools in the research laboratories of the General Electric Company.

Their purpose is to treat or melt refractory materials under conditions where no contamination with foreign material is possible.

The first consists in the use of a mercury arc either in vacuum or in an indifferent gas, and is best applicable to materials having an appreciably high conductivity. It is based on the evolution of heat which takes place at the anode of a mercury arc (constant voltage drop multiplied by current) and of the fact that most refractory materials, such as tungsten, tantalum, boron, etc., have no affinity whatever to mercury. The arrangement, which is used in a large number of modifications, can be termed a *mercury-arc furnace.*

The second method is based on the use of a high-potential arc in an indifferent gas and is especially applicable to the treatment, purification and melting of substances possessing only a very slight conductivity. This method was especially used in this boron investigation and is one of the methods used in the experiments on the dissociation of boron compounds described below.

Physical Properties of Pure Boron.—The melting point and the sublimation point of pure boron lie near together and between 2000° C. and 2500° C.

Under atmospheric pressure boron readily melts. In vacuo boron first volatilizes, more and more rapidly as the temperature is raised, until, apparently under the pressure of its own vapors, it begins to melt. When once the surface is thoroughly fused, the tendency to volatilize is greatly reduced and then the boron can be fused in vacuo with only a small loss in weight.

The accurate determination of the melting point could probably best be carried out by melting boron in hydrogen by means of a high-potential arch, the use of which is mentioned above. Dr. Weintraub has not attempted this determination; he takes his estimates of its being between 2000° C. and 2500° C., from rough comparison of brilliancy of surfaces.

The considerable vapor tension of boron, which begins to show itself in blackening the walls of the exhausted globe, already at a temperature of 1600°, makes boron as such useless as a material for incandescent filaments.

In hardness fused boron is inferior only to diamond.

The fracture of pure fused boron is conchoidal, showing no signs whatever of micro-crystalline structure. In this boron greatly resembles diamond.

It differs, however, considerably from the good specimens of black diamond in its toughness or strength. To the tremendous pressure under which diamond is formed, its characteristic toughness is usually ascribed and it is probable that if boron were fused under great pressure, it would acquire similar characteristics.

For the purpose of artificial production, which has not as yet given practical results in the case of diamond, the conditions are more favorable in the case of boron on account of its considerably lower melting point.

Dr. Weintraub then discusses the most interesting property of fused boron, namely, its *electrical conductivity.* At ordinary temperature boron is a very poor conductor, but its conductivity rises with the temperature with a very exceptional rapidity. Between room temperature (23° C.) and dull red the conductivity of fused boron increases about 2,000,000 times, a rate of increase unknown in any other element with the possible exception of selenium in the narrow range below the melting point of the latter. Above dull red the resistance still continues to go up very rapidly, and at bright-red heat boron is a relatively good conductor.

A similarly great fall in resistance is exhibited by oxides at temperatures above red heat; boron shows this behavior around room temperature, where quantitative study of the relation between temperature and resistance is possible.

For small intervals of temperature, the resistance drops geometrically for equal temperature differences; in other words, as a first approximation for not too large intervals of temperature, the resistance is an exponential function of the temperature. Around room temperature, the interval of temperature for which the resistance drops to half its value is about 17°. This interval slowly increases and is nearer 30 per cent around 300° C. Below is given one set of resistance measurements. This table has no pretentions of being accurate, as

Temperature.	Resistance in ohms.
27°	5,620,000
45	2,590,000
60	1,500,000
70	1,060,000
80	758,000
90	560,000
100	395,000
110	285,000
120	238,000
130	194,000
140	134,000
150	107,000
160	77,000
170	55,000
180	46,000

very slight errors in the temperature determination cause very great differences in the resistance. For this reason two sets of measurements never completely agreed.

The measurements at high temperatures are rendered some-

Temperature.	Resistance.
140°	107,000
160	55,000
170	40,000
180	30,500
190	22,000
210	13,000
220	10,700
250	5,300
270	2,900
290	2,250

what inaccurate, not only by the factors mentioned above, but also by some thermal e.m.fs. of small magnitude, the origin

of which has not yet been elucidated. Thus, in a second set of measurements, which agreed fairly well at lower temperatures, larger discrepancies appeared at temperatures above 100°. The next table carries the measurements up to 300°.

Finally, the same piece of boron was put into an exhausted globe and the measurement continued to see how far the resistance would drop. At beginning red (visible in a darkened room) the resistance was only 5 ohms. Thus between 27° and beginning red heat the resistance of the boron piece dropped 5,620,000 ohms to 5 ohms. The values at the lower temperature are certainly too low on account of the heat developed by the small current (1/1,000,000 amp). This is especially serious on account of the high resistance of boron, which makes the energy dissipated high even at very small currents, and on account of the small specific heat capacity of boron.

The determination of the specific resistance of boron from these measurements is somewhat difficult on account of the irregular shape of the lumps used. At 23° C. the specific resistance has the approximate value of 1.7×10^6, or about 10^{12} times that of copper.

Toward applied moderate voltages boron behaves, however, as a relatively good conductor on account of the change in resistance which takes place automatically and rapidly.

A substance with such remarkable electrical properties is naturally capable of a number of technical applications, of which the following were mentioned by Dr. Weintraub: as a motor-starting device; a sensitive pyrometer and bolometer; a wireless detector; a compensator for positive resistance changes to temperature, etc. The hardness of boron, combined with its conchoidal fracture, make it applicable to the use as jewels, dies, etc. All these technical applications are now in development.

Dissociation of Boron Compounds.—The author also studied three methods of preparing pure boron by dissociation of boron compounds at high temperatures.

1. *Magnesium boride* and similar compounds (obtained in the reaction between boride anhydride and magnesium when the first is not in excess). The dissociation begins at relatively low temperature (1200°), especially in vacuo, and is quite rapid at 1500°.

2. *Boron suboxide* (obtained in the reaction between boric anhydride and magnesium when the first is used in excess and a high temperature applied). The dissociation begins only at high temperature and is accompanied by volatilization of a part of boron suboxide (especially if it is carried out in vacuo).

3. *Boron nitride*. The dissociation of this compound only takes place at a very high temperature.

If the dissociation of these compounds is carried out in ordinary electric furnaces where the heating element is carbon, the obtained product is contaminated somewhat with carbon.

New types of furnaces have been developed in which no carbon heaters are used, or else in which the product is protected from the carbonaceous vapors.

Preparation and Properties of Solid Solutions of Carbon and Other Elements in Boron; Chemical Metallization of Carbon.—After pure boron in fused form had been prepared and its properties ascertained, an investigation was started on the influence of small amounts of other elements dissolved in boron. Carbon, silicon, magnesium, aluminium, etc., were tried. Dr. Weintraub described only the properties of solid solutions of carbon in boron as perhaps the most remarkable of all.

If carbon is introduced into boron in small amounts the cold conductivity is enormously raised and the negative temperature coefficient of resistance reduced. The effect is so great that it is not an easy matter to get accurate results. The magnitude is shown by Dr. Weintraub's statement that a few tenths of one per cent of carbon reduce the cold resistance of boron in the ratio of 12:1.

Between pure boron and boron containing about 8 per cent carbon there is a most interesting region in which almost any desired negative temperature coefficient of resistance can be selected.

The specific resistance goes down as the carbon content increases, which may be very advantageous for many practical purposes.

Above 8 per cent the temperature coefficient is of a magnitude which can be found readily in other substances.

The solid solutions of small amounts of boron in carbon exhibit still more remarkable properties.

All the known forms of carbon which conduct at all, whether amorphous carbon or graphite or carbon made by carbonizing cellulose (base of a carbon filament in incandescent lamps) or deposited from volatile hydro-carbons, have a negative temperature coefficient of resistance.

The only exception is formed by the so-called "metallized" carbon produced by the General Electric Company by heating carbon deposited from gasoline to a very high temperature in an appropriate electric furnace.

This species of carbon has a relatively low specific resistance and a positive temperature coefficient of resistance.

The same change in the properties of the carbon is produced, as Dr. Weintraub found, by incorporating into it a very small amount of boron, an amount so small that it can be detected only by flame reaction, but cannot be determined analytically; in other words, *boron has a catalytic effect, transforming metalloidical carbon into metallized carbon.*

This effect must not be confused with the well-known graphitizing action which a large number of elements have on carbon. In the case of graphitization a material is produced which drops in resistance with increase of temperature.

The metallizing action of traces of boron is specific to this element. All other elements tried, particularly iron and silicon, do not produce that result.

Whatever the cause of the peculiar action of boron, it is established that by its means the *chemical metallization* of carbon is accomplished for the first time.

It is remarkable that a substance like boron with an enormous negative temperature coefficient of resistance, when dissolved in traces in carbon, which also has a negative temperature coefficient of resistance, transforms the latter into a positive one.

Dr. Weintraub had a very interesting exhibit of various preparations of boron. The president, Dr. Baekeland, in opening the discussion, complimented Dr. Weintraub highly on his achievement. Mr. Hering asked how the boron wire exhibited had been made.

In his reply Dr. Weintraub explained that it had been produced by first making a rod by compressing, then sintering it and then depositing boron from boron chloride and hydrogen as described.

Silundum.

Prof. S. A. TUCKER presented a paper by himself, H. F. KUDLICH and E. M. HEUMANN on the preparation of silundum. Bölling's original paper on making silundum was published in this journal, January, 1909, page 24. The method employed by Bölling for converting carbon into silundum consists in heating the carbon in an atmosphere of silicon, the combination of the two producing carborundum, which is absorbed to varying depths by the carbon, depending upon the temperature and the length of time. The present authors studied the formation of silundum according to the following two reactions, yielding silicon, as the preparation of silundum appears to depend on a formation of silicon:

$$SiO_2 + 2\,SiC = 3\,Si + 2\,CO,$$

and

$$SiO_2 + 2\,C = Si + 2\,CO.$$

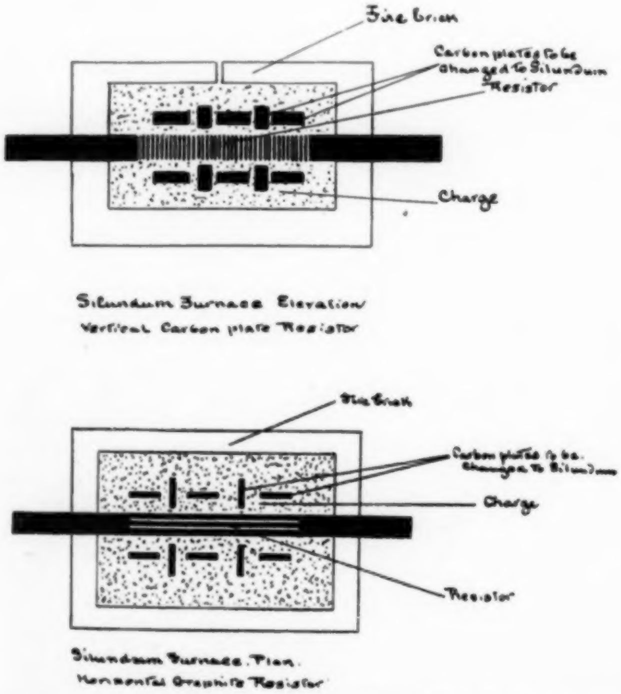
The furnace is shown on page 513. It is built of firebrick. The core instead of being of granular carbon was made by pressing together a number of small carbon plates between two horizontal graphite electrodes; the plates were 2½ in. x 1¼ in. x ⅓ in. pressed together face to face. Around their core was placed

a charge of sand and carborundum in which were imbedded at varying distances from the core the carbon articles to be changed to silundum.

The side and end walls of the furnace were concreted as tight as possible in order to prevent the ingress of air, which would tend to oxidize the silicon as it was formed. The authors described the results of eight different experiments from which it is evident that silundum can be produced by either of the two reactions mentioned above; the second reaction, employing cheaper materials, would naturally be preferable. The temperature employed seems to be about the same as that for the preparation of carborundum.

The penetration or conversion of carbon into silundum depends upon the time of the run and also on the temperature employed. The conversion of the carbon into silundum depends upon its position with respect to the core. No very careful study was made of the product; the following points were noted, however.

In appearance it is compact, of a light gray to greenish color.



ELEVATION AND PLAN OF SILUNDUM FURNACE.

It has a hardness apparently the same as carborundum and is heavy. This increase in weight over the carbon from which it is made is an indication of the more or less complete transformation of the carbon into silundum.

Its most valuable property and probable use is its ability to stand a high temperature in the air without sensibly undergoing oxidation, and as it is a conductor of electricity, its use as a resistor material.

Several experiments were made with a view to testing it in this capacity, and they pointed to a satisfactory material for temperatures up to, say, 1500° C. In one experiment a plate of silundum was placed on a graphite block and pressed on its upper surface by a vertical graphite electrode. By passing sufficient current through this system the silundum plate was raised to a high temperature and maintained so for three hours. The graphite block and electrode were oxidized to such an extent that there was very little left, while the silundum plate was not affected at all excepting the surface exposing the carbon from which it was made, which happened to be broken off. The carbon here was, of course, burned away leaving a box-like shell of silundum. The temperature was read at various times and was found to be 1200° C. and over.

The electrical resistance of the material varies greatly, depending upon the penetration, but there seems to be no reason why the material should not prove valuable as a resistor material and come into general use for a variety of purposes in which a high temperature is to be maintained electrically.

In the discussion which followed, Dr. Acheson remarked that silundum was nothing new; it was the same product which he had called silixicon. As to the real composition of silundum, Professor Tucker said that silicon vapors penetrated into the carbon; but as to the chemical composition he could give no information; it has many properties similar to carborundum. Its resistance is greater than that of carbon, but every piece of silundum seems to have its own resistivity. Mr. Tone stated that silundum consists principally of carborundum (96 per cent to 97 per cent) and silicon. Silundum, analyzed by Mr. Hansen, contained 80 per cent silicon, which is some 10 per cent more than is contained in carborundum.

Advances in Electrochemical Analysis.

Dr. EDGAR F. SMITH, of the University of Pennsylvania, delivered, by special invitation of the Board of Directors, a most interesting lecture summing up his work in the development of modern methods of electro-analysis. He explained that electro-analysis is only a small corner in the whole field of chemistry and that he had often tried to get away from it and undertake research in other directions, but that he was always attracted again by the fascination of electro-analysis.

He began working in this field some 30 years ago, when he first determined copper electrolytically on a suggestion of Wolcott Gibbs. In course of time he learned to determine other metals by electrolytic methods and to use electrolysis also for the separation of different metals, like copper and cadmium. At these early times, the criticism was often made that electro-analytic methods took too much time and were too expensive. These criticisms have been completely removed through the advances made in recent years.

Dr. Smith then showed some typical experiments with typical apparatus which he had brought over from his laboratory. One of the principal apparatus devised by him is the use of a rotating anode. This provides a good stirring of the electrolyte and thereby permits the use of a higher current density so that the analysis can be completed in a shorter time. Several experiments using the rotating anode were shown.

The second important piece of apparatus is the use of a mercury cathode for depositing metals. The amalgam formed is weighed and the metal deposited is thereby determined, while the solution is titrated for the anion, if it remains in the electrolyte (for instance, if a sulphate is analyzed with a platinum anode). It is, however, possible to catch the anion by using a special metallic anode. For instance, chlorides may be analyzed with a silver anode, the silver catching the chlorine. Other anions can be caught in the same way by the silver anode. For the determination of fluorides, calcium hydrate is put on the platinum gauze which forms the anode. An anode of this kind can be made up of a series of such layers of gauze in disk form.

A step further is represented by the use of a double-compartment cell in which the mercury acts as a bipolar electrode. This is used for the analysis of sodium and potassium salts. Sodium chloride, for instance, is placed in one compartment, the chlorine being caught by the silver anode and the sodium by the mercury which acts as cathode in this compartment. The sodium amalgam formed is brought over to the second compartment of the cell which contains water resulting in the formation of sodium hydrate. The arrangement is quite analagous to the Castner-Kellner cell. Many variations are, of course, possible. For the analysis of potassium sulphate the same double cell may be used with a platinum anode, yielding as before, potassium hydrate in the outer compartment and sulphuric acid in the inner compartment.

A very interesting and special separation is that of radium from barium. Radiferous barium chloride may be treated in

such a double-compartment cell. The radium comes out at the outside, free from barium and can be detected by its radio-active properties. The inner barium chloride solution is no longer radio-active.

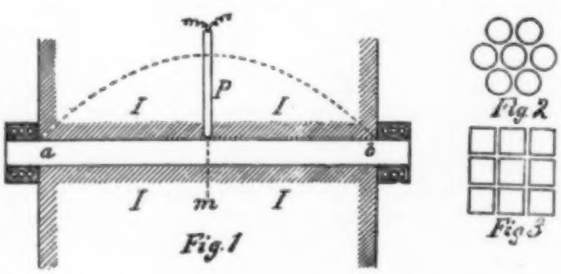
The lecture was listened to with the greatest interest, as Dr. Smith spoke in his most forceful style. He said he was not an electrochemist nor a physical chemist, but simply a chemist. He invited those who might be still doubtful about these methods to come to Philadelphia and see how they work in the hands of young unskilled students and how very uniform results are obtained in their hands.

After the lecture Professor Armstrong, of London, complimented Dr. Smith very highly. Dr. Smith might or might not be a physical chemist, but his lecture had shown him to be a very human person. It had emphasized the personal equation and explained Dr. Smith's great influence on his students.

Electrode Losses in Electric Furnaces.

In the Saturday morning session, four papers were read on this subject, the first paper being that of Mr. Carl Hering on the laws of the electrode losses in electric furnaces. The paper contains essentially the same theory which was given by Mr. Hering in his article in the October issue of this journal, although rearranged and amplified. The reader is, therefore, referred to this former article.

A second paper of Mr. Carl Hering describes a new method of measuring the mean thermal and electric conductivities of furnace electrodes. The object is to find by experiment these mean conductivities which should be inserted in his formulas



FIGS. 1 TO 3.—MEASUREMENT OF CONDUCTIVITIES.

in order to find the best ratio of length to cross-section of an electrode. The test is as follows, the arrangement being shown in Figs. 1 to 3:

Let *ab*, Fig. 1, be a rod of the electrode material to be tested, embedded in a heat-insulating material *I*, except at its ends, which are water-jacketed or otherwise cooled and kept at a constant known relatively low temperature. The refractory material *I* is assumed to be a perfect heat insulator. The cross-section of the rod is *S* square inches and the length of the embedded part is *L* inches.

Let a relatively large electric current be passed through this rod from end to end. This will raise the temperature of the embedded part, the highest being at the middle section *m*, and it will fall toward the two ends to the temperature of the water-cooled ends. A pyrometer *P* is introduced at the middle point.

When the constant current has been passed for a sufficient length of time, so that the stable state is reached, that is, until the pyrometer ceases to rise, then it is evident that all the heat generated in the rod electrically, flows out only at the two ends, as the heat insulation is assumed to be perfect. When this state has been reached, the temperature at the center and at the water-cooled ends, the current, and the voltage between the two terminals, should be measured. The product of the current and the voltage gives the heat flow in watts *W* which is leaving at the two terminals. It is not necessary to measure the heat absorbed by the cooling water, as this heat flow is determined much more readily and probably far more accurately by means of an ammeter and voltmeter.

The heat conductivity of this material is then determined from the following formula:

$$k = 0.02986 \frac{W\,L}{T\,S}$$

in which *k* is the mean heat conductivity in gram calories per second per square inch for one degree C. per inch, and *T* the difference in temperature in centigrade degrees between the maximum at the middle and that at the water-cooled ends.

From the same readings of the volts *E* and amperes *C* in this test the mean electrical resistivity for that same range of temperature is readily calculated from the formula

$$r = \frac{E\,S}{C\,L}$$

in which *r* is the resistivity in ohm, cubic inch units. This method is based on the assumption that the heat insulation of the test rod is perfect. This may be accomplished with probably no appreciable error by surrounding the test rod by a tube of the same or a similar material, which is electrically insulated from it, and which is also heated by a current to the same temperature at its middle part and cooled to the same temperature at the ends. The two heat gradients in the test rod and in the surrounding tube will then be the same, hence no heat will leave the embedded part of the test rod except the very slight amount which flows longitudinally through the cylindrical shell of heat-insulating (and therefore non-conducting) material surrounding the rod and escapes at its outer ends. If this shell is made very thin, just thick enough to insulate electrically, and the rod be made relatively large in cross-section, and long, the heat which is thus lost through this insulating material may be made extremely small, especially if the material is loosely fibrous or granular so that the actual heat insulation is practically due to the air in the interstices. Moreover, only one-half of this small heat loss comes from the test rod, the other half coming from the tube.

Instead of using a tube for obtaining this heat insulation, which may at times be difficult to do, it is much simpler and probably quite sufficiently accurate for all practical purposes, to surround the test rod with a number of similar rods embedded in the same insulating material and placed parallel and as near as possible to the test rod about as shown in Figs. 2 and 3 in which the middle one is the rod under test. The ends of each are water-jacketed like the test rod. These can then all be connected electrically in series with each other and with the test rod so that the same current heats them all; if then they are all of the same size and material, the temperature can be safely assumed to be practically the same in them as in the test rod, and it is then unnecessary to use a second pyrometer on the outer row of rods to see that the temperature is the same as that of the test rod.

* * *

A paper by Mr. C. A. Hansen, of the Research Laboratory of the General Electric Company, gave first an analysis of the electrode losses in one of his furnaces. This analysis is based on the formula that the electrode loss (the heat given off by the electrode from the cold end to the waterjacket) equals half the total Joulean heat loss plus the pure conduction loss due to temperature difference between the two ends. (See article of C. Hering in our October issue.) The furnace dealt with is shown in Fig. 4, the electrode design in Fig. 5.

The furnace has been so charged at different times that it would finish its run at 10,000 amp, 15,000 amp and 20,000 amp respectively, being kept at these current values for several consecutive hours in each case. The losses as determined in the cooling water under these conditions remain fairly constant, showing that in all probability an equilibrium has been established within the electrode. The temperature at the hot electrode end has been measured and for each case was found to be about 3200° C. The cold end of the electrode reached a temperature of approximately 200° C. The temperature difference was therefore 3000° C.

Mr. Hansen analyses the losses to see what can affect them and how far these losses are determinable from published data.

To determine the Joulean heat, or

$$C^2R = \frac{C^2\rho l}{S}$$

the current can be measured accurately enough for all practical purposes. Regarding the resistance of Acheson graphite, the only known figure is 0.00032 ohm per inch cube, given as the cold resistance by the Acheson Graphite Company. No

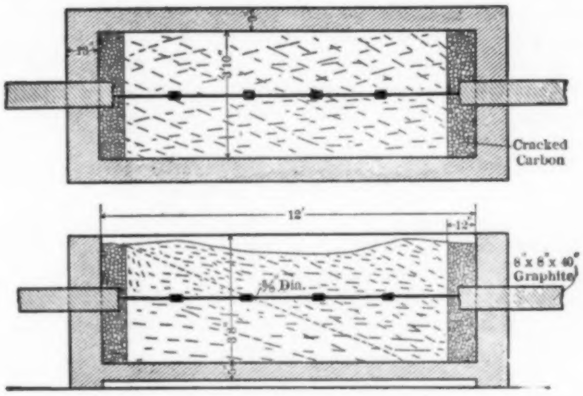


FIG. 4.—ELECTRIC FURNACE.

mention of a temperature coefficient is made. But what length of active electrode shall we use? The resistance of the terminal head is so much lower than that of the electrode within it that perhaps all of the current passes into the electrode at the extreme tip next the furnace. The electrode end within the furnace may disseminate the current in the charge all along its length. Obviously, all of the electrode length is not the resistor for the whole current carried.

As regards section, that is easier, for in all probability the carborundum packing, although it has been known to carry current (carborundum furnace), does not carry any large proportion of the current. "Skin effect" does not enter at 40 cycles, according to a numerical estimate of Mr. Hansen. This is due to the high specific resistance of the material.

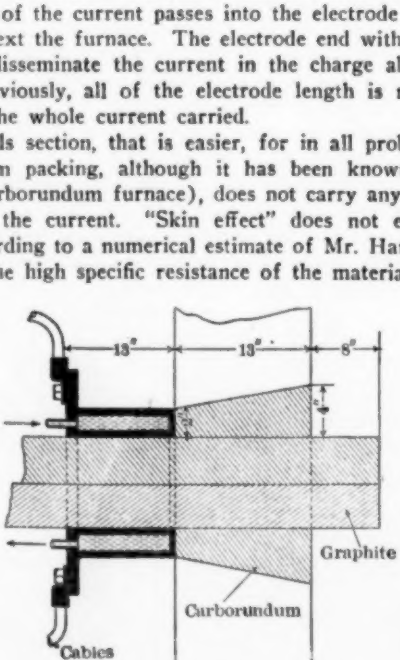


FIG. 5.—ELECTRODE DESIGN.

Second, to find the heat conductivity from the formula

$$H = K\frac{(T_2 - T_1)\,S}{l}$$

it is stated that K is known for Ceylon graphite and a few other varieties, but not for Acheson graphite. $(T_2 - T_1)$ would be assumed anyway, if the calculation were to be made. In this particular case it is known closely enough. S and l are again open to the same speculation, as in the case of the C^2R loss.

Third, contact resistance is neglected altogether in the formulae so for published.

When the current does not exceed 10,000 amp in the electrode shown in Fig. 5 the end wall remains intact. If we assume in that case that the electrode is maintained at an average temperature of 1200° C., is surrounded by a silica brick wall 10 in. thick, the outside of which is kept at room temperature, the loss of heat through the wall would only be 3.5 kw, and half of this only would, strictly speaking, be an electrode loss. This is, of course, only a very rough approximation.

When the current is increased to 20,000 amp in the same electrode, a volume of silica brick, weighing some 100 lb. to 125 lb., disappears during each run. In fact, it is almost possible to correctly guess the ammeter reading by watching the furnace fumes. Now to vaporize 100 lb. to 125 lb. of silica requires energy which would otherwise appear in the cooling water, but the silica passes up through the furnace charge and must naturally lose some of that energy as it passes through the cold top layer.

One kw-hour per pound of SiO_2 vaporized may be hazarded as a guess at the energy quantity thus removed, one-half of which should properly be added to the cooling water readings.

As it is evident that in the first place knowledge of the conductivities or resistivities of electrode materials is all important, Mr. Hansen gives the following figures for resistances of graphite and carbon electrodes:

Resistance of Acheson Graphite Electrodes.

Size of Section.	Sample Taken.	Number of Samples.	Ohms per inch Cube.	
⅛ inch diameter	Lengthwise	3	0.000391	-0.000396
¼ inch "	"	3	0.000343	-0.000379
⅜ inch "	"	3	0.000329	-0.000353
½ inch "	"	3	0.000268	-0.000290
1 inch "	"	2	0.000885	-0.000898
2 inch "	"	2	0.000363	-0.000367
3 inch "	"	2	0.000405	-0.000433
3 inch "	Crosswise	2	0.001025	-0.001030
4 inch x 4 inch	Lengthwise	2	0.000378	-0.000399
4 inch x 4 inch	Crosswise	2	0.000802	-0.000802
6 inch diameter	Lengthwise	2	0.000329	-0.000334
6 inch "	Crosswise	2	0.000655	-0.000662

The figures given are the extremes of 12 measurements made on each sample at about 25° C. The samples were cut from material taken from stock of the General Electric Company in April, 1909.

As regards the temperature coefficient, measurements were made on a ⅛-in. diameter rod in vacuo, with the following results, which the author believes represent the true resistance at a temperature not over 50° C. from that given:

Temperature, ° C.	Resistance, %
25	100
400	91.0
800	81.5
1200	66.0
1600	65.0
2000	68.0
2200	69.0

Mr. Hansen also places on record some measurements on National carbon electrodes taken from stock of the General Electric Company at various times within the last three years.

Resistance of National Carbon Company Electrodes.

Size of Section.	Sample Taken.	Number of Samples.	Ohms per inch Cube.	
⅛ inch diameter	Lengthwise	5	0.00180	-0.00113
½ inch "	"	5	0.00113	-0.00147
⅝ inch "	"	19	0.00132	-0.00193
4 inch x 4 inch	"	1	0.00180	
4 inch x 4 inch	Crosswise	2	0.00225	-0.00252
6 inch x 6 inch	Lengthwise	1	0.00337	
6 inch x 6 inch	Crosswise	2	0.00350	-0.00370
8 inch x 8 inch	Lengthwise	2	0.00234	-0.00280
18 inch x 18 inch	"	3	0.0056	-0.0100

In justice to the National Carbon Company, it is to be stated that the 18-in. x 18-in. x 72-in. carbons, last referred to, were made over three years ago, and at the time they were the largest ever made in this country. It is understood that large electrodes recently made are very much better, and in that case the resistance should be found to be very much lower than the values given.

The author has also speculated as to the probable effect of temperature on the resistance of carbon, with curious results.

Samples of ⅝-in. diameter carbon rods obtained from the National Carbon Company were fired in groups of three at various temperatures in an Arsem vacuum furnace. One batch of four samples was fired in an electric tube furnace to 3500° C. Average cold resistance values, etc., for the fired samples are given:

Temperature, ° C.	Loss in Weight. Per cent.	Linear Shrinkage. Per cent.	Cold Resistance of Fired Samples. Per cent. Original Cold Resistance.
1200	0.15	0.53	91.6
1600	0.56	0.40	87.0
2000	1.29	1.19	77.6
2400	1.64	2.38	65.9
2800	1.93	0.52	50.9
3500	2.43	0.117	22.4

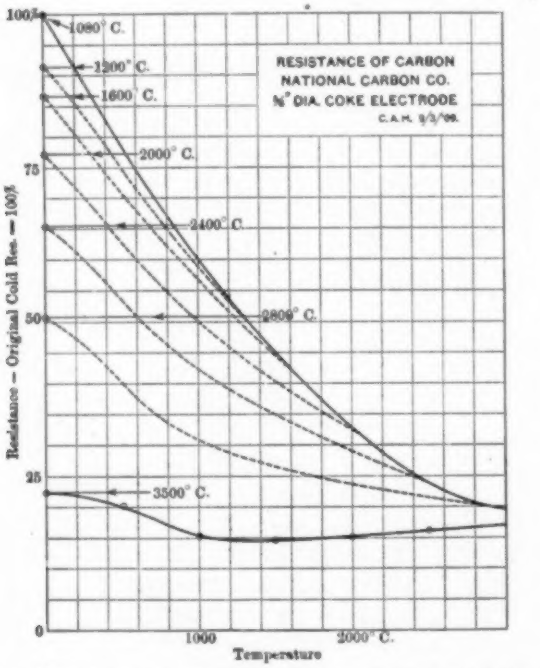


FIG. 6.—VARIATION OF RESISTANCE OF CARBON ELECTRODE.

The resistance of the 3500° samples, i.e., 0.000307 ohms per inch cube, is practically the same as that given for graphite.

Fig. 6 shows where the speculation as to the temperature resistance diagram for carbon comes in. If we attempt to measure the temperature coefficient of resistance and, in the course of our measurements go to a temperature higher than that at which the carbon was originally fired, the curve will not return upon itself on cooling down. For instance, if we go to 1200° C. and cool off, the curve will return not to 100 per cent, but to 91.6 per cent; if cooled down from 1600° it will return to 87 per cent, etc., until finally, if fired to 3500° C., it will return upon the curve for graphite, since the amorphous carbon is no longer amorphous carbon, but graphite.

There is no reason to suppose that, when we exceed the maximum temperature to which the carbon has previously been fired, there is a break in the resistance curve. The curve for any carbon will be a smooth one, hence the dotted curves are all drawn tangent to the parent curve. For all of the commercial carbons, the temperature coefficient of which the author has measured, the 1200° hot resistance is around 60 per cent of the cold resistance. Upon the assumption that the 1200° resistance is about 60 per cent of the cold resistance for National Carbon Company electrode material fired to various temperatures and upon the assumption that all of the branch curves are tangent to a common curve, the extreme ends of which are located, the curves shown are a reasonable derivation.

If, now, we assume a straight line gradient in our electrode and a temperature difference between hot and cold ends, as in the case under consideration, of 3000° C., the effective resistance of our graphite electrode will be the true average resistance of graphite as determined by averaging a lot of resistance ordinates equally spaced along the temperature axis of the temperature-resistance diagram for graphite. So, for graphite, this is fairly simple when we have the "constants." For $T_2 - T_1 = 3200° - 200°$ C., the average is about 78 per cent of the cold resistance.

With carbon, on the other hand, if the electrode has been alternately heated and cooled several times, different points in its length being heated to different temperatures, the working resistance of the electrode may be anything at all. Any point within the triangular area of Fig. 6 will be sure to fit out some point in the electrode with its proper "constant." Let as assume, however, that, as for graphite, the average ordinate along the parent curve holds. For our furnace and carbon electrodes, the effective resistance is then 40 per cent of the original cold resistance, or, for 4-in. x 4-in. x 40-in. electrodes, 0.00072 ohms per inch cube.

Electrode resistance was actually measured under the operating conditions. The results will be taken up later.

Effective Length of Electrode and Contact Resistance.

These are treated together by Mr. Hansen, for they are to a certain extent interdependent.

The length of our electrode may be divided into three portions and the portions treated separately. These portions are:

1. The length within the furnace itself.
2. The length embedded in the furnace wall.
3. The length within the brass terminal.

1. Inspection of the experimentally determined temperature gradient for a carbon electrode similar mechanically to the one under consideration[1] leads to the conclusion that practically all of the current is carried to the extreme electrode tip, making this entire length an effective length.

2. It is safe to assume that practically all of the current is carried by the electrode portion embedded in the furnace wall, making this entire length an effective length.

3. With the length within the brass terminal, which is over 38 per cent of our entire length, contact resistance enters to affect the effective length of conductor.

The author considers the terminal and electrode multiple conductors from cable contact to the terminal tip next the furnace wall, and that the contact between the two is equally divided between the two ends of the terminal. See Fig. 7.

B = resistance of brass terminal.
G = resistance of graphite electrode.
$C = C^1$ = contact resistance.

The ratio of the current carried via BC^1 to that carried via CG becomes $C + G$ to $B + C$.

G, taking 0.000350 ohm per inch cube = 0.000071 ohm.

B, taking brass at 0.0000032 ohm per inch cube = 5 times resistance of copper = 0.0000013 ohm.

If we neglect contact resistance, we find that 98.2 per cent of the current goes via BC^1, as against 1.2 per cent via CG. In other words, the current will be crowded into the electrode at the terminal end next the furnace wall, making very little of the length within the terminal an effective length. If the contact resistance is great as compared with G and B, then the current will be evenly distributed throughout the contact area, making one-half the length in the terminal effective conductor for the whole current, but in that case contact resistance must inevitably be a factor for consideration in calculating the electrode losses.

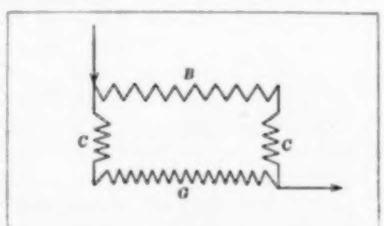


FIG. 7.—CURRENT THROUGH TERMINAL.

[1] Trans. Am. Electrochem., 15, 292.

Some time ago the author built a furnace with the resistor made up of carbon motor brushes, each 2 in. x 2 in. x 7/16 in., with a resistivity in inch ohm units of 0.00120. These brushes were piled flatwise in a vertical column and were in good mechanical contact with one another. Pressure was applied to the column by means of a screw, but the pressure was not measured. Mr. Hansen judges it to be in excess of 200 lb., or over 50 lb. per square inch of contact.

The cold column had a contact resistance over 100 times the resistance of the brushes themselves, figured as a solid carbon column. At 1800° the contact resistance was at least 20 times the resistance of the carbon.

This indicated that it would be worth while to look into the contact resistance question a little more closely.

Accordingly, an attempt was made to actually measure the contact resistance of the furnace terminals under operating conditions. It would perhaps have been simpler to measure the contact resistance of a column of plates, alternating graphite with brass, and it was intended to do this in case the projected experiment did not yield results.

It is no easy or extremely accurate matter to determine the resistance of a conductor carrying 15,000 amp or 20,000 amp alternating current by means of a voltmeter, and the results obtained are intended merely to give the approximate magnitude of the loss.

A 1¼-in. diameter graphite rod was threaded vertically into the tip of electrode within the furnace, and this rod projected some 4 in. above the charge. A terminal was threaded to the end of the graphite rod, another into the cold end of the electrode, and a third connection was made to the brass terminal. The voltmeter leads were twisted together and brought out to the voltmeter, which, of course, was protected as much as possible from stray fields. The only loop in the voltmeter circuit was the rectangle bounded by electrode graphite rod, voltmeter lead and furnace wall, 34 in. x 26 in. in dimension.

The results obtained were as follows: E being the potential drop:

Run of September 8, 1909. (Graphite electrode as in Fig. 5.)

		Terminal to Hot Electrode End.			Tip to Tip of Electrode.			Contact.		Water.
Time.	Current.	E.	Kw.	R. Ohms.	E.	Kw.	R. Ohms.	E.	Kw.	R. Ohms.	Kw.
8:30	Start										
9:30	3840	2.3	8.80	0.00060	1.0	3.84	0.00026	1.3	4.96	0.00034	2.4
10:00	4080	2.3	9.40	0.00056	1.0	4.08	0.00024	1.3	5.32	0.00032	2.6
10:30	6000	2.8	16.80	0.00047	1.0	6.00	0.00017	1.8	10.80	0.00030	4.5
11:00	6480	2.8	18.15	0.00043	1.1	7.13	0.00017	1.7	11.02	0.00026	5.2
11:30	9600	3.2	30.70	0.00033	1.2	11.51	0.00013	2.0	19.19	0.00020	12.0
12:00	10500	3.2	33.60	0.00030	1.3	13.65	0.00012	1.9	19.95	0.00018	14.0
12:40	12700	3.2	40.70	0.00025	1.8	22.85	0.00014	1.4	17.85	0.00011	20.5
1:10	13200	3.1	40.90	0.00023	2.0	26.40	0.00016	1.1	14.50	0.00007	21.0
1:45	14900	3.4	50.70	0.00023	2.2	32.80	0.00015	1.2	17.90	0.00008	29.9
4:15	16080	3.4	54.7	0.00021	2.2	35.40	0.00014	1.2	19.30	0.00007	37.5
4.45	16800	3.6	62.0	0.00021	2.3	38.60	0.00014	1.3	21.80	0.00007	36.8
5:10	17280	Cut off power, 3272 kw-hours in furnace.									

Actual water record was taken to correspond only with the three last readings. The other water losses are taken from previous runs; they all check to within a few per cent when compared on the basis of current if the power curves are at all comparable, and, as a rule, they are comparable. The terminal was in excellent shape mechanically—good contacts—drawn up as tightly as four standard ¾-in. bolts would safely stand without stripping threads.

The resistance data is plotted in Fig. 8.

Contact resistance is certainly a factor worth considering. To get back, then, to Fig. 4:

$$B + C = 0.0000013 + (2 \times 0.00007) = 0.0001413 \text{ ohm.}$$

$$C + G = (2 \times 0.00007) + 0.000071 = 0.000211 \text{ ohm.}$$

Current carried via $BC = 60$ per cent as against 40 per cent via CG. The resistance of the multiple circuit is 0.0000845 ohm, which leaves only 0.0000145 ohm for the graphite electrode. In other words, only 20.4 per cent of this portion of our electrode is effective conductor for all of the current. It would also be added that decreasing the contact resistance or increasing the resistance of the electrode itself diminishes this effective length percentage.

For the purpose of this paper, however, the author thinks we are justified in making the 20 per cent value above developed a general value.

Also contact resistance, which has so far been neglected in all formulas for the calculation of electrode losses, must somehow be brought into those formulas. Its value is dependent upon current density at least, and as well upon temperature of contact, nature of contact, whether oxidized or not, etc., but for our own purpose, since all but current density is fairly constant, the values per square inch for it may be obtained by

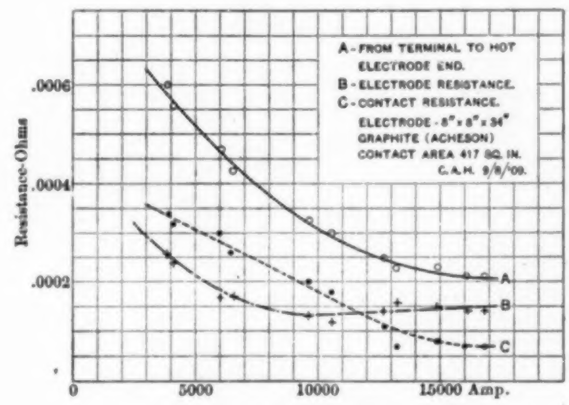


FIG. 8.—RESISTANCE DATA.

multiplying the resistances given in curve form (Fig. 8) by 417—the contact area in square inches.

It is also curious to compare the contact losses here measured with some which the author proposed last May as perhaps giving the magnitude of this loss.

"*Contact Resistance Between Waterjacket and Electrode.*

"Based on brush to commutator resistance at 2 lb. per square inch pressure, equivalent to 832 lb. distributed pressure on an 8-in. x 8-in. electrode in a 13-in. waterjacket.

1. 10,000 amps in terminal = 24 amps per square inch contact.
   [2]$r = 0.036$ $R = 0.0000865$ $C^2R = 8.65$ kw.
2. 15,000 amp in terminal = 36 amp per square inch contact.
   $r = 0.026$ $R = 0.0000625$ $C^2R = 14.05$ kw
3. 20,000 amps in terminal = 48 amp per square inch contact.
   $r = 0.023$ $R = 0.0000553$ $C^2R = 22.12$ kw.

Comparing these results with the data determined, we have:

Current.	R.	C^2R.	R.	C^2R.	
10,000	0.0000865	8.65	.00018	19.95	
15,000	0.0000625	14.05	.00007	19.30	
20,000	0.0000553	22.12	.00006	24.00	(exterpolated value)

We can now also arrive at fair valuations of both electrical resistivity and heat conductivity.

Electrical Resistivity of Graphite.[3]

Electrode composed of four pieces 4 in. x 4 in. x 40 in. bundled together.

The resistance of an average Acheson graphite electrode used with a temperature range $T_2 - T_1 = 3200 - 200°$ C., by actual measurement is then 0.00037 ohm per inch cube.

By cold resistance and temperature-resistance diagram, the

[2] r = resistance per square inch of contact.
[3] Same as detailed above.

same electrode should have a resistivity of 0.00030 when the lengthwise resistance figure is taken.

Time.	Current.	Resistance.	Resistivity (Ohms per inch Cube).
9:30	3840	0.00026	0.00070
10:00	4080	0.00024	0.00064
10:30	6000	0.00017	0.00045
11:00	6480	0.00017	0.00045
11:30	9600	0.00013	0.00035
12:00	10500	0.00012	0.00034
12:40	12700	0.00014	0.00037
1:10	13200	0.00016	0.00043
1:45	14900	0.00015	0.00041
4:15	16080	0.00014	0.00037
4:45	16800	0.00014	0.00037

Mr. Hansen prefers to favor the lower value of resistivity and to adopt the value of 0.00032 ohm per inch cube as the working value for these extreme limits of temperature variation.

Heat Conductivity.

From the experimental data obtained by measuring the cooling water losses of carbon and graphite electrodes not carrying current, as previously described, it is also possible to assign conductivity figures to both carbon and graphite.

Graphite "idler":

$l = 12.75$ in. $\qquad T_2 = 2830°$ C.

$S = 16.0 \qquad T_1 = 30°$ C.

Loss = 3580 watts.

K for graphite = 1.65 watt seconds/sec./° C./ for 1 in. length and 1 sq in. section.

= 0.162 (c.g.s. units.)

Carbon "idler":

$l = 12.75$ in. $\qquad T_2 = 3500°$ C.

$S = 16.0 \qquad T_1 = 30°$ C.

Loss = 445 watts.

K for carbon = 0.165 watt seconds/sec./° C./ for 1 in. length and 1 sq. in. section.

= 0.0162 (c.g.s. units.)

In connection with this last experiment, Mr. Hansen replies to Mr. Hering's criticism of it (this journal, Vol. VII, page 400): "Comparing different materials experimentally by means of electrodes of the same size is equally incorrect and misleading; it also leads one away from the goal, rather than toward it."

Mr. Hansen's reply is: "I fail to see how the comparison would be improved by resorting to electrodes of different sizes. Grant that we did not have enough of an idea of 'constants' involved to calculate a loss directly. Would we then gain by gratuitously making the conditions such that no single factor would be the same for the two materials to be compared? In either case, whether the electrodes are of the same size or of different sizes, a set of conditions is experimentally determined. Without resorting to doubtful 'constants' and doubtful dimensions, a comparison of some kind may be made if the electrodes are of the same size, whereas without resorting to 'constants,' of which even the approximate magnitude was unknown, no comparison whatever is possible, if the electrodes are of unlike sizes. Again, in these experiments both electrodes—carbon and graphite—were run at current densities, which cannot be practically maintained even in the graphite electrodes, densities which were then extraordinarily high for carbon. The attempt was made to cover the entire practicable range of both electrodes, and comparisons at different current densities for the two electrodes can be made with greater security by interpolating the data obtained on like sizes than would be possible in the other case."

We have now the most important data for calculating losses.

The electric resistivity of graphite under conditions applicable to a temperature difference of 3000° C. is 0.00032 ohm per inch cube = 0.000812 ohm per centimeter cube. The electric resistivity of carbon under the same conditions may be taken as 0.00072 ohm per inch cube, or 0.00183 ohm per centimeter cube. Ratio of carbon resistance to graphite resistance under these conditions is 2.25.

The heat conductivity of graphite 3200° C. to 200° = 1.65 watt-second per second per degree Centigrade for 1 in. length and 1 sq. in. section = 0.162 c.g.s. units. The heat conductivity of carbon under the same conditions is 0.165 watt-seconds per second per degree Centigrade for 1 in. length and 1 sq. in. section = 0.0162 c.g.s. units.

Contact resistance may be taken as 0.075, 0.029 and 0.025 ohm per square inch for brass to graphite at current densities through the contact area of 24 amp, 36 amp and 48 amp per square inch, respectively.

Calculation of Losses for Titanium Carbide Furnace Electrodes.

Material, graphite.

$T_2 - T_1 = 3000°$ C.

Section = 64 sq in.

Length = 27¾ in.

Current = 10,000 amp, 15,000 amp, 20,000 amp.

Heat loss is the same in each case.

$$H = K \frac{(T_2 - T_1)\, S}{l} = \frac{1.3 \times 3000 \times 64}{23.75} = 10.55 \text{ kw}$$

$$C^2R \text{ loss} = \frac{C^2 \rho l}{S} = C^2 \times \frac{0.00032 \times 27.75}{64} = C^2 \times 0.00011.$$

$C = 10{,}000 \quad C^2R = 11.8$ kw., $\quad C^2R/2 = 5.9$ kw.

$C = 15{,}000 \quad C^2R = 26.6$ kw., $\quad C^2R/2 = 13.3$ kw.

$C = 20{,}000 \quad C^2R = 47.2$ kw., $\quad C^2R/2 = 23.6$ kw.

Total loss $= H + C^2R/2$ (no account taken of contact resistance).

According to this formula, then, the losses for 10,000 amp, 15,000 amp and 20,000 amp will be 16.45 kw, 23.85 kw and 34.15 kw, respectively.

The contact resistance losses are 19.95 kw, 19.30 kw and 24.00 kw, respectively, for 10,000 amp, 15,000 amp and 20,000 amp.

If we add all of this to the losses previously calculated we get, respectively, 36.40 kw, 43.15 kw and 58.15 kw.

If we add half of it only, we get, respectively, 26.42 kw, 33.50 kw and 46.15 kw.

The corresponding losses actually measured by cooling water methods are 22 kw, 28 kw and 36 kw.

The losses as calculated from the curve sheets given in a previous paper[4] are 21.2—34.4, if we for once exterpolate the curve sheets given, 42 kw, respectively.

Putting these results together in table form we get:

Current.	A	B	C	D	E
10,000......	16.45	36.40	26.42	22.00	21.2
15,000......	23.85	43.15	33.50	28.00	34.4
20,000......	34.15	58.15	46.15	36.00	42.00

$$A \text{ Loss} = \frac{C^2R}{2} + H$$

$$B \text{ Loss} = \frac{C^2R}{2} + H + \text{Contact } C^2R$$

$$C \text{ Loss} = \frac{C^2R}{2} + H + \frac{\text{Contact } C^2R}{2}$$

D Loss = Measured in cooling water.

E Loss = Curves based on measured losses for 4-in. x 4-in. graphite electrodes.

The discrepancy between D and E at 15,000 amp and 20,000 amp is, the author believes, in part, a measure of the losses from electrode to furnace wall. The major part of the wall loss is, however, no doubt, due to volatilization of silica, which makes the actually measured losses low.

As a conclusion, then, Mr. Hansen thinks that either column C or E (i.e., either the losses calculated from loss =

$$\frac{\Sigma\, C^2R}{2} + H,$$

or the losses as calculated from the curve sheets given)[5] more nearly approximate the true losses than either the losses ac-

[4] Electrochem. and Met. Ind., 7, 358.
[5] Electrochem. and Met. Ind., 7, 358.

tually measured in cooling water *at high-current densities,* or those calculated from heretofore published formulas.

Fortunately, we can considerably improve upon our contacts by increasing the number of electrodes which make up a given section, and then making use of the increased surface afforded by these separate electrodes, as, for instance, by providing individual threaded caps.

Since in this case the contact area is not necessarily a function of the dimensions of the entire composite electrode, the equation $\frac{1}{2}\ C^2R + H = \text{Loss}$, where C^2R refers only to the actual electrode resistance, should be of value in calculations for the minimum-loss-electrode dimensions.

Mr. Hansen then criticizes the statement of Mr. Hering that the design of electrodes should not be based on figures of current density. Mr. Hansen prefers to combine the best ratio of l to S found from electrode losses, with the permissible current density, as follows:

He prefers, in connection with his own work, to take a current density of 150 amp per square inch for graphite, and 50 amp per square inch for carbon electrodes, since he knows from experience that when he exceeds these densities for any considerable period, his end wall is badly corroded. On this basis and solving Mr. Hering's equation for dimensions for a 20,000-amp electrode, he finds a ratio of length to cross-section = 0.278 if inch-units are used.

At a current density of 150 amp per square inch, the graphite electrode would have a section of 133 sq. in. and an effective length of 37.0 in.

Calculating the dimensions of a carbon electrode to do the same work, he found that with the "constants" here given l/S should be 0.0585. At 50 amp per square inch, this means an electrode 20 in. x 20 in. in section and 23.4 in. effective length.

The minimum loss for the graphite electrode would be 34.4 kw if we can assume that contact loss can be reduced to zero or nearly zero. The minimum for the carbon electrode would be 16.9 kw.

The ratio of minimum losses is 2.04 in favor of carbon.

It is also evident that the equation

$$\frac{l}{S} = \frac{1}{C}\sqrt{2\ (T_2 - T_1)\frac{k}{\rho}}$$

(which is the same equation as Mr. Hering's, except that here the heat conductivity k is measured in watt-seconds) may be converted into

$$l = \frac{1}{d}\sqrt{2\ (T_2 - T_1)\ \frac{k}{\rho}}$$

where d = current density.

If we assume that 50 amp for carbon and 150 amp for graphite are good current densities for general work, and that the "constant" K and ρ hold for most work, we can solve for length directly:

$$l = \frac{1}{150} \times \sqrt{2\ (T_2 - T_1)\ \frac{k}{\rho}} = 0.69\sqrt{(T_2 - T_1)}$$

for graphite and

$$l = \frac{1}{50} \times \sqrt{2\ (T_2 - T_1)\ \frac{k^1}{\rho^1}} = 0.43\sqrt{(T_2 - T_1)}$$

for carbon. l is expressed in inches, $(T_2 - T_1)$ in deg. C.

In furnaces of the Héroult type, operating conditions require current densities in the electrodes of 30 amp or less per square inch, but in no other case that Mr. Hansen recalls would these equations have so little bearing in determining the electrode dimensions as in the present types of steel furnaces. Protection for the exposed terminals and a maximum uninterrupted downward feed are the determining factors in this work, aside from the choice of an electrode section which is great, relative to the area of the bath surface.

* * *

The fourth paper on the subject of electrode losses in electric furnaces was presented by Dr. E. F. ROEBER. In the introduction of this paper it is shown that the formulas as developed by Mr. Hering are based on the assumption of constant thermal and electric conductivities. Since this is an assumption which is not realized in practice it is important to investigate how much of the basic principles of the theory will hold good for more general conditions.

The problem is attacked in two different ways. The first way starts, like the classical mathematical theory of heat and like Mr. Hering's theory, from the investigation of an infinitely small particle. It is investigated what happens there and the fundamental differential equation is established. This is then integrated first under the assumption that both the thermal and the electric conductivities are linear functions of the temperature.

The investigation is restricted to the practically important case in which no heat passes in either direction through the hot end of the electrode, since this is the condition under which electrodes are preferably operated and which should form the basis of electrode design. In this case the hot electrode end is at exactly the same temperature as the furnace charge next to it.

A somewhat complicated formula is found giving the ratio of length to cross-section which an electrode must have in order to fulfill this condition, if the temperature T_0 at the hot end and the temperature T_1 at the cold end are given, if the current i is given and if the two conductivities are known linear functions of the temperature.

Three special cases of this solution are those in which either the electric conductivity or the heat conductivity or both conductivities are independent of the temperature. If both conductivities are independent of the temperature a formula identical with that of Mr. Hering is obtained. Also if the electric conductivity alone is constant and independent of the temperature while the thermal conductivity is a linear function of the temperature, it is proven that the formula for constant conductivities is correct, if in it the arithmetic mean value of the thermal conductivity between the two given temperatures is inserted.

The theory is then extended to the most general case in which the two conductivities are assumed to be distinct functions of the temperature, but nothing whatever is assumed concerning the nature of the functions.

For this most general case the following fundamental principle is proven: If no heat passes in either direction through the hot electrode end within the furnace, while the current i passes through the electrode, the ratio of length to cross-section equals the reciprocal value of the current i, multiplied by a value which depends only on the electrode material and the two temperatures T_0 and T_1 at the two ends of the electrode. The only two assumptions made are the condition of stationary operation (the temperature being independent of the time) and the condition that no heat is given off by the electrode sideways to the refractory walls.

In the second part of the paper the electrode is considered at once as a whole, so that the investigation is not based on differential calculus. The assumptions are made that the condition of operation is stationary (the temperature at any point remaining constant in time) and that no heat is given off from the electrode to the surrounding walls.

Under these conditions, the heat A (positive or negative) flowing from the furnace inside through the hot electrode end into the electrode, and the heat B (always positive) flowing from the electrode through the cold end to the outside (for instance, to the waterjacket) have distinct values, which depend on the special conditions under which the stationary operation of the furnace takes place.

It is then always possible to write A and B as the difference and sum respectively of two other values x and y.

$$A = x - y$$
$$B = x + y$$

This involves, of course, no assumption at all. It is so far simply a play with mathematical symbols. But it is easy to see that x and y have a distinct physical meaning.

By subtracting A from B, we get,

$$y = \frac{B - A}{2}$$

$B - A$ is the difference of the heat which flows out of the electrode at the cold end and the heat which flows into the electrode at the hot end. Since according to the assumption no heat flows through the side walls of the electrode, $B - A$ must be the total Joulean heat generated within the electrode. Hence $y =$ one-half the total Joulean heat.

Further, it is evident that $x = \frac{A + B}{2} =$ half the sum of the two heats flowing into the electrode at the hot end and out of the electrode at the cold end (both measured in the same direction).

Hence we have a superposition of two phenomena: First, a flow of the same heat $x = \frac{A + B}{2}$ through the two ends in the same direction, and second, a generation of Joulean heat $2y$ within the electrode from electrical energy, this heat flowing off impartially one-half $(+y)$ to one side and one-half $(-y)$ to the other side.

So far everything is very simple. But the trouble is that in the general case we cannot consider the two phenomena independently of each other. The heat x is not "the heat which would flow if there were no current." Both the temperature drop from the hot inside to the cold outside and the generation of Joulean heat are responsible for the temperature gradient within the electrode. Hence the Joulean heat affects the temperature and therefore the heat conductivity at any point so that the heat flow x is not the same as though no current were flowing, because in the latter case the temperature and the heat conductivity at any point would have different values from our case.

In quite the same way the Joulean heat $2y$ is not the same as though there was no temperature drop from the hot to the cold end, because the latter affects the temperature gradient and therefore the electric conductivity at any point and therefore the Joulean heat.

Hence the two phenomena of simple heat conduction x and Joulean heat production $2y$ are not independent of each other in general.

But whatever the function which determines the dependence of the conductivities on temperature, the condition under which no heat passes through the hot electrode end in either direction, is given by the equation $x = y$. Or in words, the heat conduction due to the temperature difference at the two ends must equal half the Joulean heat. Since the two terms cannot be calculated independently in general, it is preferable to stop here with the analysis and to rely upon the experiment for further developments.

The author proposes to use Mr. Hering's method of measurement (see abstract above, Figs. 1, 2 and 3), but not to determine the mean values of the two conductivities, but directly the best ratio of length to cross-section.

This can be done in the following manner, which is free from any theoretical objection, since it is based on the general rule proven before in the paper, that whatever may be the functions which determine the two conductivities in their relation to the temperature, it is generally true that the product of the current i and the ratio of length l to cross-section s depends only on the two temperatures T_0 and T_l at the two ends and on the electrode material, if no heat shall flow through the hot electrode end in either direction. This rule may be stated also in this way: Whatever may be the functions which determine the two conductivities in their relation to temperature, it is generally true that the product of the length of electrode and current density depends only on the two temperatures T_0 and T_l at the two ends and on the electrode material, if no heat shall flow through the hot electrode end in either direction.

The latter assumption is fulfilled for the arrangement shown in Fig. 1 in Mr. Hering's paper for either half of the electrode from the center to one of the two ends. The temperature at the center is a maximum $= T_0$. The temperature T_l at the ends is maintained constant by water cooling or some other arrangement. Then it is possible to find the characteristic curve giving $l\,i/s$ as function of the temperature T_0.

Assume that we make a test with graphite. We will use a rod $a\,b$ of length $2l$ and cross-section s. We keep the temperature T_l at the two ends a and b constant, for instance, by water cooling, and we measure the temperature T_0 at the center and the current i. Then according to the theory $\frac{l}{s}\,i$ must depend solely on T_0.

By raising the curent i from zero upward and waiting till equilibrium is established, every increase of current i will produce a rise of temperature T_0. We can then prepare a table or plot a diagram with the temperature T_0 as abscissas (T_0 always greater than T_l) and the value $\frac{l}{s}\,i$ as ordinates.

The theory states that if we repeat the same experiment with another rod of length $2l'$ and another cross-section s' and if the current which produces the maximum temperature T_0 at the center is now i', the value $\frac{l'}{s'}\,i'$ for any temperature T_0 must be the same as in the preceding set of experiments. This would be the most direct and crucial test of the correctness of the theory and of the proper execution of the measurement.

When this is done, the diagram we have plotted will directly answer the question of the best ratio of length of cross-section to be selected for any graphite electrode with water-cooled end (temperature T_l), if the temperature T_0 of the furnace and the current i are specified. We would simply find from the curve in the diagram the value $\frac{l}{s}\,i$ which corresponds to the given temperature T_0 and by dividing the value $\frac{l}{s}\,i$ by the given current i, we find the best ratio of l to s.

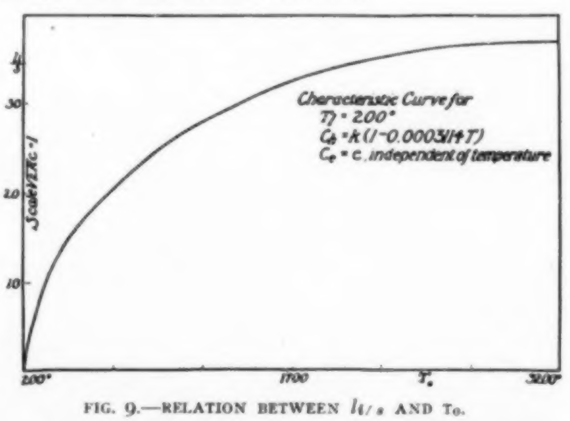


FIG. 9.—RELATION BETWEEN $l\,i/s$ AND T_0.

Of course, the diagram will answer likewise the question what current i would have to be employed with an electrode of given length l and cross-section s in order to use it under best conditions (so that no heat flows in either direction through the hot end) for a given temperature T_0 at the hot end.

Any characteristic curve of this kind holds good only for the same material and for the same temperature T_l of the cold end. For any other material and for any other temperature T_l of the cold end, other characteristic curves must be plotted. To give a rough idea of the general character of such a curve, Fig. 9 gives the theoretical curve for an electrode material which (like graphite, according to Mr. Hansen) has, at 200° a thermal conductivity 270 times that at 3200°. But the heat conductivity c_h is assumed to be a linear function of temperature, and the electric conductivity c_e to be independent of temperature. The cold end of the electrode is maintained at a constant conductivity of 200°.

There was quite an extended discussion of the subject of electrode losses, participated in by Messrs. Hansen, Hering, Richards, Grower, Lidbury, and Arsem, while a communicated discussion of Dr. Kennelly gave a graphical representation of the laws of electrode losses in form of a diagram.

Explosive Antimony.

A paper by Dr. R. C. PALMER on "a new electrolytic method for the preparation of explosive antimony" was presented, in the author's absence, in abstract by the Secretary. The paper gave a history of the production of explosive antimony and then described experiments of the author on the electrolysis of non-aqueous solutions of antimony trichloride. Acetone is a suitable solvent. The best conditions for carrying out the electrolysis were established. The deposit has the characteristic flaky deposit.

Perchloric Acid.

A paper by Mr. FRANK C. MATHERS on a method of producing perchloric acid was presented, in the author's absence, in abstract by the Secretary. The perchloric acid is produced from sodium perchlorate by treating with an excess of hydrochloric acid. The paper was only of a preliminary nature, as the author proposes the use of perchlorate baths for electroplating.

Practical Conductance of Electrolytes.

A paper on this subject by Profs. JOSEPH W. RICHARDS and WALTER S. LANDIS was presented by Dr. Richards. The paper discusses the actual conductance of the electrolyte in electrolytic refining tanks as the same are ordinarily set up and operated.

In almost all refining tanks the edges of the anode and cathode plates are at some distance from the sides and bottom of the tanks. The free space, that not directly included between the plates, is a field through which stray current flows, the current lines being usually curved. It adds considerably to the conductance of the electrolyte. The authors have measured experimentally the conductance of these lateral or bottom prisms

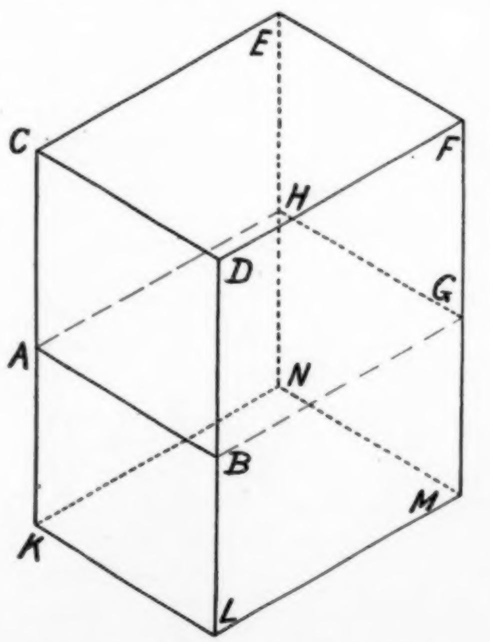


FIG. 1.—ARRANGEMENT OF EXPERIMENTS.

of electrolyte in order to see to what extent they influence the conductivity of the electrolyte as a whole.

The method used was to place two electrodes *ABCD* and *EFGH* (Fig. 1) of pure copper in a neutral copper sulphate solution against the ends of a glass cell, which they completely covered (in the figure they are shown raised from the bottom). Readings of current and voltage allowed the calculation of the conductance (equal to the ratio of current to voltage) of the cell as a whole. The plates were then raised by intervals of 1 cm and the conductance of the cell determined each time as before. From the conductance of the cell as a whole as thus measured at each interval of rise was subtracted the conductance of the prism of electrolyte *ABCDEFGH* directly between the plates leaving the conductance of the bottom prism *ABKLMNGH*. The conductance of the bottom prism was then compared with its full conductance, i.e., that measured between opposite parallel plates and the percentage which the former

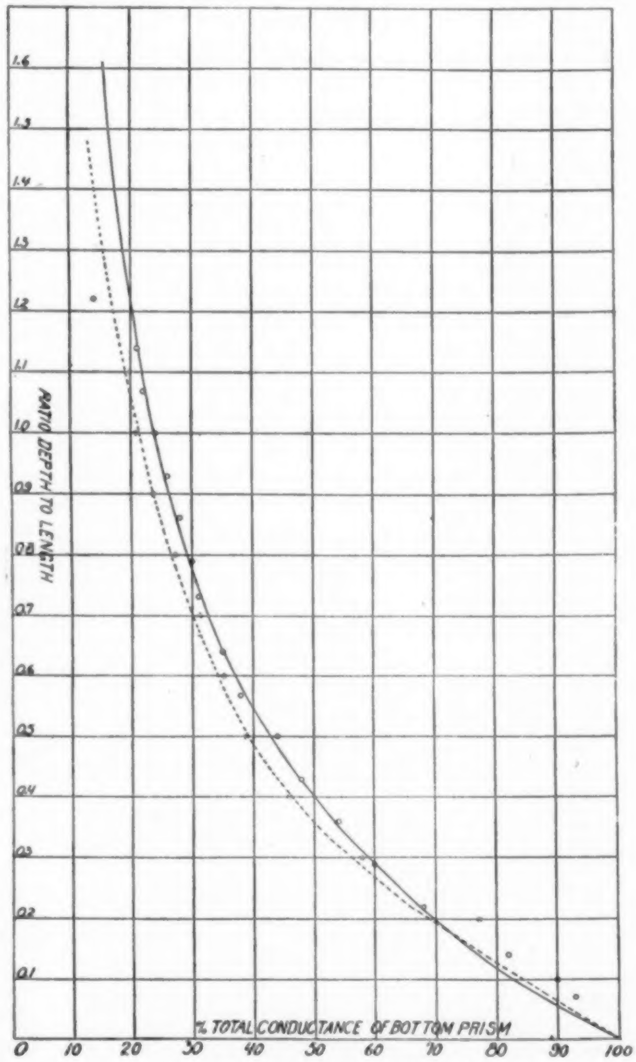


FIG. 2.—RESULTS OF EXPERIMENTS.

formed of the latter recorded. Similar experiments were made with cells of different dimensions.

It was found that while the conductance of the bottom prism was different for different lengths between the plates, its percentage conductance, as calculated above, was practically constant for any given ratio of depth of solution *AK* under the plates to length of solution *AH* between the plates. The authors have, therefore, plotted, in Fig. 2, the percentage conductance of prisms below the plates, taking as ordinates the ratio of depth to length and as abscissas the percentage as calculated above.

For zero ratio the conductance is, of course, 100 per cent, and for an infinite ratio it is zero. An interesting observation is that for a given conductance between the plates the conductance of the prism below the plates reaches a maximum at a finite increase in depth and thereafter remains constant. In several of the authors' experiments this maximum conductance was reached with a ratio of depth of approximately 0.5. They have plotted, in Fig. 3, the percentage which the actual conductance bears to the determined maximum for the prism beneath the

plates, the ordinates again representing the ratio of depth to length and the abscissas the percentage of the maximum.

In order to determine whether the conductivity of the electrolyte affected the values determined as above, they tested electrolytes of widely varying conductivity with approximately identical results, and, furthermore, tested sheets of copper, tin foil and zinc, the most careful experiments being made with zinc, and the ratio determined from it practically duplicated the ratios obtained from the copper sulphate electrolyte. The results obtained on the zinc are shown in Fig. 2 by the dotted line.

In cells in which the electrodes did not exactly fit the ends they also attempted to determine the conductance of the prism of electrolyte not directly underneath the electrodes, but to one side, i.e., Fig. 4, the prism *CNOKLGPQ*, diagonally under the electrodes and which may be considered to have connection with the electrodes at the corners *C* and *G*. In making these determinations electrodes *ABCD* and *EFGH* were used smaller than the ends of the cell and were also raised up successive centimeters, leaving besides the prism *ABCDEFGH* directly between the plates and the side prisms *CDKSLGFT* between the edges of the plates and the side of the tank, the bottom prism *BCMNQRHG* between the bottom edges of the plates and the bottom of the tank, and the diagonal bottom prism *CNOKLGPQ*. The conductance of the cell being measured for each successive withdrawal of the plates, the sum of the conductance of the prisms between the electrodes, at the side of the electrodes and directly under the electrodes, was subtracted from the measured conductance in order to determine the residual conductance ascribable to the bottom diagonal prism. The number of factors to be considered in this measurement left the determination of the conductance of this bottom diagonal prism rather unsatisfactory. From three or four carefully conducted experiments the authors can but say that the conductance of such a relatively large diagonal prism as would be encountered

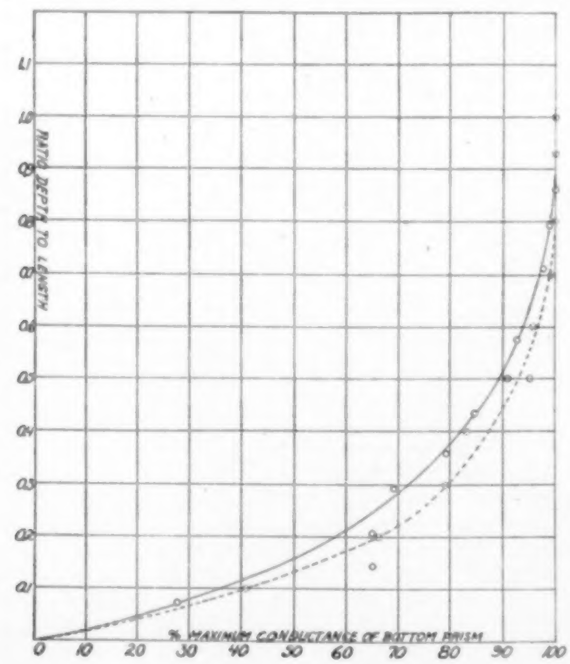


FIG. 3.—RESULTS OF TESTS.

in practice does not appear to add sensibly to conductance of the cell as a whole.

Practical Conclusions.—There results from this study the conclusion that the practical conductance of the electrolyte situated between the two electrodes, both directly, lateral and beneath the electrodes, can be calculated by adding to the conductance of the portion between the plates the conductance of the side and bottom prisms as determined in each case by calculation from the respective conductance of the prisms as if between parallel plates and the use of the constant as given in the curve in Fig. 2. It is only necessary to find the ratio of depth (distance from edge of plate to side or bottom of tank) to length (distance between the plates), to refer to the curve and to find the percentage of total conductance o feach prism actually available. The conductance of the diagonal bottom prism may be neglected in all cases in actual practice.

The fact that there is reached a maximum conductance after

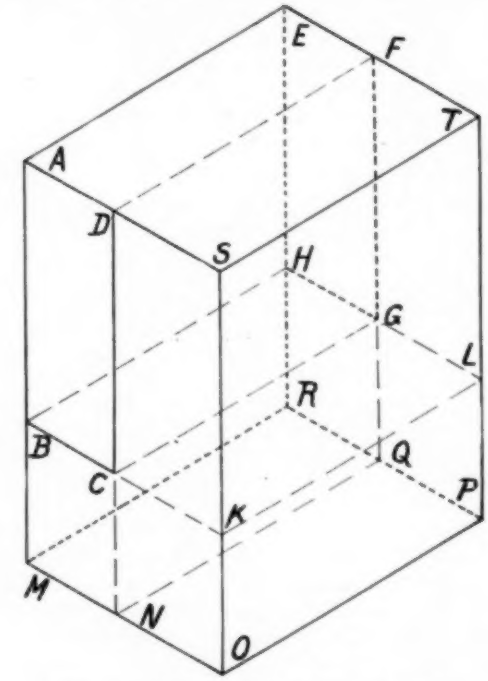


FIG. 4.—ARRANGEMENT OF EXPERIMENTS.

a given depth, holding for electrolytes and metals both, is important as showing the uselessness of increasing the depth of the electrolyte underneath or at the sides of the electrodes past a certain point, such increase in dimensions adding nothing to the conductance. The uselessness of increasing the depth (width) of an electrical metallic conductor conducting between points of contact at the two ends on the same side, beyond a certain depth which is approximately the ratio of depth to length of 1/5, is quite as important for the electrical engineer, in the design of equalizing bars and heavy busbars of short length, and shows the great importance of making contact over the whole end or face of the conductor in order to get the full utilization of the metal comprising it. Connection should never be made along an edge or at the corners.

The papers of Professors Richards and Landis was discussed at some length by Dr. W. R. Whitney, Mr. Townsend Wolcott, Dr. M. Loeb, Mr. E. A. Sperry, Mr. Carl Hering and Dr. L. H. Baekeland. Dr. Richards replied for the authors.

Prevention of Corrosion of Steel.

The last paper of the Saturday morning session was presented by Mr. Maximilian Toch on a new method of preventing the corrosion of steel. This was based on an observation made by Mr. E. A. Sperry to the effect that pieces of steel, obtained from detinning tin scrap, were rendered immune against corrosion by treatment as cathode in a sodium carbonate solution of certain concentration at a low voltage and a high amperage. Mr. Toch has made experiments along the same lines and thinks that such a method may prove practical for protecting bolts, nuts, screws, etc., against corrosion.

In the discussion, Mr. Gaines suggested that in some cases of corrosion bacteria play a part. Mr. Toch affirmed this for some cases of corrosion of copper. The paper was also discussed

by Messrs. Sadtler and Sperry. Mr. Sperry will present a further paper on this subject at the next meeting.

The first two papers of the afternoon session dealt with dry cells, one by Mr. F. H. LOVERIDGE, with "dry-cell tests," the other by Prof. C. F. BURGESS and Mr. CARL HAMBUECHEN, with "some characteristics of dry cells."

Dry Cells.

Mr. F. H. LOVERIDGE, in his paper, thought that it would seem to be a very desirable thing to have dry cells rated on an amphour or a watt-hour basis under some definite condition of energy discharge, but such a thing is practically unknown at the present time. The rating we now have is that of dimensions of the cell and its current. The first might be accepted as reasonable, but the second is misleading. Amperage ratings are high and apparently based on the instantaneous current a cell will give when short-circuited through a low-resistance ammeter. Such readings are of practical value in discovering defects, but so far as determining an energy output is concerned they are of little value.

The "shelf test," or, in other words, the test made after a cell has remained for a certain time in storage, is one that serves a useful purpose for the reason that it is desirable to know the change that takes place during such period. Very few cells go into service immediately after they are made and during the delay more or less deterioration takes place. But in such tests high-resistance voltmeter and a low-resistance ammeter should be used—a minimum of 150 ohms for the voltmeter and a maximum of 1/100 of an ohm for the ammeter are found to be satisfactory values.

Taking everything into consideration, Mr. Loveridge comes to the conclusion that the best shelf test is one that compares the actual performance under working conditions of the cell after a certain length of time on shelf with that of a new cell. In this way results are obtained that involve no factors of uncertainty. There is involved in this the using up of cells to find out what they will do on life test. Such procedure, however, seems necessary since other methods involving tests not absorbing energy are not dependable and sample cells used up on life tests do not represent very great expense.

Deterioration is shown by an increase of internal resistance inasmuch as voltage readings decrease very slightly on shelf. It is impossible to give any exact data as to the increase of internal resistance on shelf because there is such a wide variation even in cells of the same make, but, roughly, it might be said that a reduction in the short-circuit current of 50 per cent would be a fair average in one year at ordinary temperatures.

Life tests are often made on dry cells by connecting them permanently in circuit with a fixed resistance. This method is the easiest one to employ as it requires no attention other than the taking of readings at the desired intervals. Such a test is of no great value, however, as the energy output is small and the life very short unless the current is kept low. Under these conditions the staying qualities of the cell are not demonstrated and the ability of the cell to stand up under ordinary current drain after a considerable period on "open-circuit" service cannot be predicted with safety.

There is a wide variation in the energy derived from cells discharged with constant resistance down to 0.5 volt under these varying conditions. The value of the energy output in different cases has been figured to a point at which the potential difference has fallen to 0.5 volt and is found to be as follows:

With	1 ohm	7	watt-hours.
"	2 ohms	8	"
"	4 "	14	"
"	6 "	21	"
"	10 "	24	"

As the "closed-circuit" test is not a safe one for "open-circuit" work, the best test to be applied is the "open-circuit" one in which the cell may be made to show what its life characteristics are when its energy is used over a relatively long period. Sample cells are generally taken for this purpose, and tests should duplicate working conditions as nearly as may be. Some form of clock-controlled contacts are very well adapted to this purpose and may be made to control the open and closed-circuit periods in any manner desired. It is also a good plan to use relays controlled by clock contacts for closing the test circuits. By this means the master or pilot contacts on the clock are only used for light currents, and it is much easier to maintain them in good condition. The mechanism and contacts should be well made and reliable, as it is difficult at best to get consistent results. The shorter tests, as a rule give results more satisfactory as regards uniformity than long ones—the chances for variable factors entering being greater with increased time.

In taking readings on dry cells it is, of course, necessary in either "closed" or "open-circuit tests" to have some form of voltmeter to measure the e.m.f. It is also desirable to use such an instrument for current readings employing the fall of potential method, as this enables current readings to be taken without disturbing circuit connections. If an ammeter is inserted in circuit from time to time, there is a tendency to vary contacts and resistance. Anything tending to introduce variations should be carefully avoided.

Mr. Loveridge showed numerous curves giving the results of various tests. From one of them it was seen that there is a continual increase of the internal resistance of a dry cell as energy is given out. The internal resistance is very low when the cell is new; as the cell grows older on the shelf the resistance is continually increasing, though to a much smaller extent, than when it was on even very light service. The internal resistance depends, both on life and service.

Another set of curves of Mr. Loveridge showed the results of intermittent tests. Other curves referred to ignition service. It is difficult to form an adequate idea of the energy requirements for ignition service. The resistance as well as adjustment of spark cells is very variable and the time of service, as, for instance, in automobile work, is apt to vary between wide limits.

In striving to obtain the highest efficiency, it is necessary to know working conditions, such as current drain or resistance of circuit and the frequency and duration of circuit closure. Knowing these factors, the proper arrangement for the required number of cells can be made to obtain the best results. It is frequently found that cells in parallel may be advantageously employed for the reason that excessive current drains may thus be avoided. The characteristic action of cells indicates that under heavy current drain the fall of potential is rapid and the energy obtained is small, hence the plan of placing "enough" cells in series may not be advisable. A high potential may be maintained by placing cells in parallel so that the current drain on each will be light. Such a plan utilizes the energy available in a far more efficient way.

Tests are sometimes made in which a fixed current is caused to flow, but in order to accomplish this, the resistance must be constantly changed. Such tests are interesting, but the conditions are not those ordinarily met in practice. A constant-current flow is desirable, however, and a very close approximation to it may be made with dry cells, provided they are arranged for the high-level rate of discharge.

One of the important factors in obtaining data from dry-cell tests is the "cut-off" point, or, in other words, the value to which the potential difference of the cell may be allowed to fall before it is considered exhausted. The lower a cell is run, the greater will be the energy obtained, but this is offset by the greater variation in potential difference. Hence a compromise must be made. A study of conditions must govern the selection of this point in various classes of service, but it should be remembered that it involves one of the most important elements in obtaining best results.

The battery gage is a factor in the situation that must be con-

sidered. As a rule, these instruments are constructed as a species of volt-ammeter in that they are either high-resistance ammeters or low-resistance voltmeters. As they are not expensive it can hardly be expected that they will compare favorably with Weston instruments in exactness of indications. The scale divisions generally indicate amperes, and the intention is to show what current would flow if the cell were short-circuited through a low-resistance ammeter. The coil of the battery gage being of only a few ohms resistance, there will be a variation in current depending on the internal resistance of the cell—the deflections of the needle will be approximately proportional to the current strength. When the internal resistance has increased to a considerable extent, the battery gage is capable of giving a good indication of it. Thus, when a cell is exhausted, a battery gage is convenient and fairly reliable for indicating the condition of the cell.

Battery gages are not reliable for detecting small variations in the condition of a cell, nor for determining accurately any exact condition. Where exact conditions are desired, the best that can be done is to allow the normal working current of the cell to flow and then take a potential difference reading with a standard high-resistance voltmeter. Such readings give the best indications of the stage a dry cell has reached in the period of its useful life.

In conclusion, Mr. Loveridge expressed the hope that before long some standard tests may be proposed which will be generally accepted as determining the rating of dry cells. The number consumed annually is enormous and users are obliged to accept them with no information which will give a definite idea of energy output. They must judge of this by experience. The art of manufacturing dry cells has progressed to such a point that a reliable product is obtainable, and dry cells should fall in line with other electrical products as a standard article with a definite rating.

The paper elicited quite an extended discussion, in which Dr. Baekeland, Dr. Waldo, Mr. Loveridge, Dr. Sharp, Professor Burgess, Dr. Whitney, Mr. Hering and Dr. Elliott participated. Professor Burgess spoke of the advantages of constant-current tests, but Dr. Sharp thought that the main argument in their favor was their greater convenience with a number of cells connected in series, while constant-resistance tests resemble more nearly the conditions of practice.

Mr. Hering moved that the society should undertake the formulation of standardization rules on dry cells. This motion was seconded by Dr. Whitney, who emphasized that it was the duty of the society to undertake just such work.

The motion to appoint a committee for this purpose was carried unanimously.

* * *

A paper by Prof. Charles F. Burgess and Mr. Carl Hambuechen discusses the desirable characteristics of a dry cell, which naturally depend upon the service with which it is to be associated.

Dry cells are used in the telephone field, in ignition service, electric-bell and annunciator work, with telegraph and alarm circuits, electric clocks, phonographs, etc.

The primary requisites of a dry cell are its ability to live over a long period of time, a low internal resistance, minimum polarization and rapid recovery. It is impossible to point out which is the most important of these qualities, since the relative importance depends upon the character of service required. Among the minor characteristics which are sought to be attained in dry-cell construction are: Absence of the leakage of the liquid, minimum increase of resistance with low temperature, convenience for connecting into circuit, and the general appearance of the cell.

The factors which govern the above characteristics include these: Materials employed in construction, the proportions of materials, the chemical and physical qualities of these materials, methods of assembling.

In spite of the fact that 40,000,000 or thereabout represents the number of dry cells manufactured each year in this country, little scientific work has been done in the way of making a detailed study of the various individual factors which influence the quality of the cell, if we may judge by the meager publications. On the other hand, much scientific work has undoubtedly been done, if we may judge by the marked improvements which have been effected in the product. It appears that dry-cell manufacturers who are doing the larger part of this work do not feel inclined to discuss analytically dry-cell construction.

Perhaps 80 per cent of the dry cells made and used are of the so-called No. 6 size, being in cylindrical form, the zinc container 6 in. high and 2½ in. in diameter. As far as the cylindrical zinc container is concerned, there is striking uniformity in dimensions and construction, the principal difference being in the thickness of the zinc, which may be found to vary from No. 7 to No. 11 sheet zinc gage.

All cells employ a carbon rod for the cathode plate. In some forms of cells this rests on the bottom layer of paper, and in others it is raised ½ in. from the bottom. It extends up through a pitch seal, and a brass cap or brass screw attached to the top constitutes the positive terminal of the cell. Some of the carbons used are of smooth cylindrical shape, while others are corrugated or flutted to give greater contact surface to the filling material.

Another striking similarity in most of the dry cells is the list of materials which are introduced into the zinc container. Similarity then ceases, and we encounter variations in the quality of the materials, the proportions, and in the methods in which the materials are introduced into the container.

The following list and proportion of materials may be taken as fairly representing the filling mixture in well-known types of cells: 10 lb. of manganese dioxide; 10 lb. of carbon or graphite, or both; 2 lb. of sal ammoniac; 1 lb. of zinc chloride. Sufficient water is added to give proper amount of electrolyte to the cell, and the most suitable quantity depends upon the dryness of original materials, fineness, quality of paper lining, etc.

While these are the essential elements, other materials are frequently added—such as starch or other forms of paste, to improve contact of electrolyte to zinc and promote distribution of action throughout the charge. Mercury is occasionally added to effect amalgamations and prolong life of the zinc.

With the materials as above listed and in the proportions named the resulting cells may be good or they may be practically worthless, depending upon various factors. It is generally believed that purity of materials is the pre-eminent requisite. Commercial conditions, however, prohibit the use of chemically pure materials. The customary specifications for manganese dioxide calls for a granulated or powdered material having about 85 per cent of MnO_2 and less than 1 per cent of iron. This is a specification which can readily be complied with, and by careful selection and concentration it is possible to get as high as 92 per cent.

Physical qualities, porosity and size of grains are likewise important. The amount of available MnO_2 differs according to the chemical test employed, and "available MnO_2" by test may not be the available MnO_2 under the conditions existing in the cell. In storage batteries PbO_2 is an active material only when in suitable contact or proximity to grid or framework of the positive plate; and MnO_2 in a dry cell is active to a degree, depending upon its contact with the conductive carbon constituting the negative electrode. It is evident that penetration into the interior of a piece of MnO_2 is necessary if the entire mass is to be active; and porosity seems, therefore, to be important.

The purpose of the manganese is to effect depolarization, and thereby to maintain the voltage of the cell during discharge. The qualities designated "minimum polarization" and "great recuperative power" are dependent largely upon the amount and availability of the MnO_2 employed.

Carbon in a powdered or granulated form is employed to give conductivity to the mass of MnO_2 and to furnish a large amount

of cathode surface. Retort carbon, coke, petroleum coke and ground carbon rods and electrodes are the various grades of carbon commonly employed for this purpose, and much of the variation found in dry cells is due to varying qualities of this carbon. Graphite is another form of carbon extensively employed in dry cells, and the more recent improvement in dry cells is undoubtedly due largely to the liberal use of this highly conductive though more costly form of carbon.

Sal ammoniac of a very pure grade is generally employed, and in addition to purity, the physical qualities of dryness and freedom from lumps are requisite to ensure proper mixing with the carbon and manganese.

The zinc chloride is also required to be of high purity and to be free from iron.

Sheet zinc constitutes the anode and serves at the same time as a container. Purity is naturally of importance. The purchaser does not have, however, a variety of grades of zinc to choose from.

This anode makes contact with the electrolyte in the form of paper saturated with solutions of zinc and ammonium chlorides. Ideal conditions call for a corrosion of zinc only in amount equivalent to the current delivered to the external circuit. Excess of corrosion above this amount is caused by local action, and one of the principal problems in dry-cell manufacture is to reduce such local action to a minimum.

Local action is caused to a small extent only by solder, although the latter is decidedly electronegative to the zinc, but it is composed of two metals, lead and tin, both of which have high "over-voltages," which almost entirely prevent current flowing to these metals at the expense of and under the e.m.f. set up by the zinc. Some experimental cells made from sheet zinc streaked with solder on the inner surfaces showed little if any abnormal deterioration due to local action even after standing for several months.

On the other hand, copper or iron, but especially copper (which may occasionally find its way from the brass terminals into the cell), when coming in contact with zinc will set up destructive local action.

It occasionally happens that some of the filling material, the manganese oxide and carbon, gets between the paper lining and the zinc. This naturally gives rise to damaging galvanic couples. Also inequalities in the zinc itself may cause certain differences in potential.

If we were to assume all inequalities of the zinc electrodes to be removed, we still have opportunities for local action due to inequalities in the electrode on the other side of the soaked paper. Non-uniformity in the mixture is detrimental. Some manufacturers place the carbon rod in direct contact with the saturated paper resting on the bottom of the cell, the mixture surrounding it. This must necessarily give rise to some difference of potential, and a measurement of this gave a value of 0.176 volt, in such direction that current tends to flow from the carbon through paper to zinc, thence through paper to the manganese mixture and back to the carbon. To prevent this source of local action is probably the reason for the majority of cells now being made with the mixture interposed between all portions of the carbon surface and the paper.

While the carbon rod is generally considered to be the cathode, the really active cathode surface must be considered to be of a more extended structure. The carbon rod is surrounded by a mass of material—carbon, graphite and manganese—possessing metallic conductivity even though moistened by electrolyte. It would, therefore, be more accurate to consider the active cathode surface as that portion of the mixture just within the paper. While this may be the main cathode surface, it is not exclusively so, and the active surface progresses inward as the action of the cell goes on.

The cathode is a compound one, consisting of an intimate mixture of conductive carbon and graphite in contact with manganese oxide, and the e.m.f. of the cell is the summation of the electrode potentials, 0.56 volt for the zinc (against Ostwald's standard electrode), and about 1 volt for the carbon-manganese oxide mixture, or a combined voltage of 1.56.

While the cell delivers current to the external circuit this voltage decreases, the rapidity depending upon the amount of current drawn. If it were not for the manganese dioxide the drop in the voltage would be very rapid, and the value of the cell is, therefore, dependent largely upon the active manganese oxide or depolarizer. This manganese oxide is consumed. As commonly stated, it is reduced to Mn_2O_3, and in undergoing this change it becomes inactive both as a depolarizer and as a conductor. It is probable that the MnO_2 possesses sufficient metallic conductivity to contribute something to the conductivity of the cell, and when changed to the lower oxide it loses this conductivity. It thus becomes inert and occupies valuable space. It is natural to assume that the MnO_2 in the outer portions near the paper is the first to become reduced, the action progressing inward to a certain depth, this depending upon various factors, such as the intimacy of contact between the carbon and MnO_2, the purity, fineness and porosity of the latter, etc.

If the MnO_2 possesses metallic conductivity and makes contact with conductive carbon and both are moistened with electrolyte, there is a possibility that a certain amount of chemical action occurs owing to the voltaic couple thus produced.

A typical dry cell gives from 10 amp-hours (when short-circuited and run down in one hour) to 30 amp-hours. The open-circuit voltage is 1.5 or 1.6. A fair figure for the effective voltage during useful life is 1 volt for a discharge rate of 30 amp-hours, so that a fair energy rating is 30 watt-hours. During life the resistance of the dry cell increases, partly due to drying out, but more so on account of other reasons, like the partial reduction of MnO_2. Another reason is the accumulation on the surface between the paper and the zinc of non-soluble impurities of the zinc and the various basic salts and double salts resulting from the electrolytic corrosion.

When a cell is first made up, the paper is saturated with a solution of zinc and ammonium chlorides. More zinc chloride is added as a result of the corrosion of the zinc. The increasing concentration of the $ZnCl_2$ in the presence of the ammonium chloride gives just the conditions which are needed for the production of various double chlorides, some of which are much less soluble than the single chlorides.

These insoluble double chlorides occupy the pores and spaces in the paper, crowding out the electrolyte and increasing the resistance. If ammonia is liberated, it may react with the $ZnCl_2$ to form a precipitate of ZnOH, which likewise clogs the cell, unless sufficient ammonia be present to redissolve this precipitate. That this clogging action occurs at the paper and proceeds inward toward the carbon rod is evident, since in taking apart a run-down cell there is usually found a hard crust of ⅛ in. or more in thickness just inside the paper.

It is no doubt true that improvement in dry-cell construction must come through reducing this accumulation of insoluble non-conductive material. It may be suggested that this precipitation due to double chlorides might be delayed by using only NH_4Cl in the electrolyte to begin with, and, in fact, a somewhat greater amp-hour output can be obtained in this way. But it involves the more serious disadvantage of shortening the life of the cell on open circuit. The presence of $ZnCl_2$ in the electrolyte decreases in marked degree the local action.

The authors conclude that, although marked improvements have been realized, there is still need of and a possibility for improvements. A new method of rating dry cells by energy output should also be adopted. This can only be done after determining and generally adopting the standard methods for conducting tests.

This paper was also discused at some length.

Nitric Acid from Air.

A paper by Dr. SCHÖNHERR described in great detail "the manufacture of air-saltpeter by the process of the Badische Anilin und Soda Fabrik."

Since all the essential technical details described in the

paper were already given in an illustrated article on page 245 of our June issue, reference to this article must suffice here. It should, however, be stated for those especially interested in the subject of fixation of atmospheric nitrogen, that the paper is quite elaborate and covers 34 pages.

Power for Electrolytic Copper Refining.

Mr. W. L. Spalding, of the University of Buffalo, presented an interesting paper on this subject.

Power is an important item in the cost of electrolytically refining copper. Per ton of product it is less than in many electrochemical industries, since with soluble anodes the voltage factor of the power is used mostly in overcoming the ohmic resistance of an electrolytic and metallic circuit and meets no opposing electromotive force from decomposition of the electrolyte. Nevertheless, this item is in round numbers 40 per cent of the cost of converting anode to cathode copper, or 20 per cent of the cost including furnace treatment. Its relative size, though not its actual, is increased by the extensive use of labor-saving machinery and mechanical handling of material. This use has been so far perfected that further reduction of costs must most easily be obtained through lower power charges.

In securing cheap power, there are several considerations which greatly aid the refiner. First, the unchanging resistance and the continuity of the process allow a constant load day and night, and the steadiness and magnitude of the power used insures the economy either of its generation at the plant or of its purchase from a power company. Secondly, waste-heat boilers on the reverberatory and cupola furnaces furnish considerable power at little expense, since the item of fuel is entirely eliminated from its cost, and were there a sufficient amount of it, the refiner would not need to seek farther. Its one disadvantage is its irregularity. For several hours during the day the furnaces are being dipped, charged or repaired, and furnish little steam, while for a couple of hours in the morning during poling they give a large quantity. The amount of this power available for electrolytic work depends upon the material treated at the refinery; one commencing with pig copper or anodes, as is usual in the East, receives relatively a much smaller amount than one smelting ores or concentrates.

Power for electrolysis may be either generated by steam engines, gas engines, or hydraulic turbines, or purchased from a power company. Steam engines, because of their reliability, are most commonly used; any available steam from waste-heat boilers may be used in them directly by connecting these boilers in parallel with the coal-fired boilers, or the former may be used as preheaters and connected in series with the latter. Both reciprocating engines and turbines are met with, but the former more frequently, because of their high efficiency at full load, the availability of floor space at a smelter, and the lower speed which allows them to be direct connected to the direct-current generators.

The high thermal efficiency of gas engines suggests, as an attractive possibility for a refinery, a central battery of gas producers, which furnishes both power for generating electricity and fuel for heating the furnaces.

The purchase of electric power from a power company is very desirable electrically and under some conditions is the most economical. If alternating-current power is received, the units for supplying the tank house circuits are synchronous-motor generator sets which give a high efficiency of conversion, a 100 per cent power factor, great facility of operation and regulation, and practically uninterrupted service. A refinery thus equipped should be the most favored customer of the company, as with proper regulation the load curve is absolutely flat, and no interest charge on machinery held in reserve can equitably constitute a portion of the rates.

Moreover, the refinery may be used for filling up the valleys in the company's load curve and the refiner may be able to contract for additional blocks of power, at such times as the company directs, for a figure lower than for his steady 24-hour load. It is true that the current density will increase at these times, but as the deposition of copper can proceed satisfactorily under a wide range of current density, this fluctuation is not open to the same objection as in processes that require a fixed minimum voltage or a constant supply of heat.

A calculation of the saving from this cheaper power should involve the consideration that the cost of power per ton of copper is nearly proportional to the current density, and too great an increase in the density will overbalance the lower rate.

On the other hand, other steps may be taken to materially lessen this increase. The tanks with insoluble anodes used for depositing excess copper from the electrolyte may be placed in circuit only at these times; each consumes about eight times the energy of the ordinary tank, due to electrolytic decomposition, so that if their number is 2 per cent of the total, their resistance is 14 per cent of the total. A certain number of other tanks are also regularly short-circuited during the day for cleaning. Also it must be borne in mind that the current density is proportional to the square root of the power and hence its variation is less than that of the power.

In Buffalo the cost of Niagara Falls power in lots of 500 hp or over is $27.50 per hp-year, which converted to direct-current at 87 per cent efficiency equals $31.60, surprisingly large for a region situated near a source of vast water-power. Unfortunately for the consumer, there is but one company owning a franchise in the city, and it has been able to keep the field free from rivals and itself from adverse legislation. The price of power is therefore determined, not by competition with other power companies, not by cost of production, but by competition with steam-power.

The refiner who wishes to use both waste heat and electric power for electrolysis is confronted by the interesting problem of combining the two so as to secure minimum cost per ton of output. The most satisfactory way seems this—to supply a tank-house circuit with two generators in parallel, one driven by a motor running on a constant amount of the purchased power, the other driven by a steam engine whose load varies with the steam.

This arrangement permits the load to be divided in any ratio between the two generators by hand or automatic regulation of the shunt field rheostats, or the engine to be shut down on Sundays and during the dipping of the furnace charges when the supply of steam is not more than sufficient for driving air compressors, pumps, etc., and heating or evaporating the electrolyte. At large ratios of the two loads the equilibrium is delicate, but not disturbed. When taking the load off both machines and the rheostats are not turned simultaneously, one may overpower the other, but as the direction of rotation of a shunt-wound generator is not changed when run as a motor, no harm is done.

A series arrangement of the generators with half the circuit interposed between them would divide the voltage between the tank-house terminals and decrease the current loss through grounds, but excessive sparking from commutation of the heavy amperage in the weak field would not allow the engine-driven generator to carry as small a load at periods of low steam.

It is not economical to use the waste power on an independent circuit, as part of the time it would receive little or no current; the output of copper with a given power is proportional to the square root of the number of tanks and the electric power could be used to great advantage if spread out over this circuit.

To determine the number of kw-hours to be bought each month, a calculation of the amount necessary for the desired production should be made, the probable power from steam deducted, and the remainder maintained as a constant load on the motor. When the power paid for is the maximum two-

minute peak occurring in the month and these peaks are recorded by a graphic wattmeter, close regulation is essential. This can be obtained by hand regulation aided by a bell alarm, or better still, by an apparatus that automatically changes the resistance of the shunt-field circuit of the generator when the wattmeter on the motor circuit records more or less than the desired quantity. With this attachment, the maximum two-minute variation from the average load will be less than 5 kw. This combination of power necessarily gives a current density greater at night than at day, but the fluctuation is not objectionable and can be decreased as already mentioned. Further uniformity can be secured by using the peak of the steam for storing up heat in the electrolyte at night, and by rearranging the schedule so that the periods of dipping do not coincide.

The practicability of the use of electric power from central stations for refining copper has a direct bearing on a problem that is receiving considerable attention in the industrial world —the problem of meeting, on the one hand, the demands of the electrochemical manufacturer for cheap power, and, on the other, the desire of producers of electrical power to obtain customers who maintain a constant load, or, who, better yet, can use large amounts of it at times when the rest of the producer's load is light. The magnitude of the scale on which electrolytic copper refining is now conducted makes the availability of cheap power an important consideration in the location of the refinery; and at the same time such a plant is an ideal customer for the power company. The existence of these common interests makes certain a mutual profit from their mutual recognition.

Iron Copper Alloys.

A paper by Prof. CHAS. F. BURGESS and Mr. JAMES ASTON, of the University of Wisconsin, was presented by Professor Burgess.

The influence which copper has in iron and steel has for long been a subject of controversy and contradiction. It is only comparatively recently that the effect has been investigated systematically and some of the doubt eliminated.

The prevalence of appreciable quantities of copper in the ores of certain districts makes important a knowledge of its effect, detrimental or otherwise, when present in small amounts. Also, the intimate relation of copper, nickel and iron, and the beneficial effect of the addition of nickel to iron and steel, creates an interest in the influence of larger percentages.

The older opinion was that copper was deleterious; that its chief effect was analogous to that of sulphur in that it rendered iron red short and destroyed its welding power. This view was taken by many eminent metallurgists, some even contending that 0.5 per cent makes steel worthless. Others claimed that the influence was greatly exaggerated, and instances were cited where rolled sections of 0.50 to 0.75 per cent of copper did not display red shortness.

Within recent years more systematic investigations have been made to determine the effect of additions of varying percentages of copper to iron and steel. The authors then gave a review of the numerous former investigations on this subject, which were generally made to excuse the presence of copper and steel and to break down the seeming prejudice. They then gave an account of their own experiments, which form part of extended research work carried out at the University of Wisconsin, under the grant of the Carnegie Institution, of Washington (other parts of this investigation have been dealt with in various articles in former issues of this journal). They prepared their copper and iron alloys from electrolytic iron 99.7 per cent pure and pure electrolytic copper. This is of importance as, from the results of former investigations, it appears that the influence of copper on the qualities of steel varies with the amounts of carbon and sulphur present. In the present investigations these were practically eliminated, although some carbon was present; its quantity may be taken as well under 0.1 per cent.

Forging.—Alloys up to 2 per cent of copper forge well at low heats. Those from 2 to 7 per cent will not forge at a low heat, and rather poorly at white heat, the ease of workability varying inversely as the percentage of copper. From 7 to 75 or 80 per cent the alloys may be classed as non-forgeable. Between 80 and 100 per cent they will forge at a fair red heat, but not at a normal forging heat for iron.

Segregation.—The forgeable samples between 0 and 8 per cent of copper and a few of the alloys of high copper and low iron were made into tests bars for investigating the tensile strength. Random samples were analyzed by Booth, Garrett & Blair, of Philadelphia. The results show an exceedingly close agreement between the added copper and the actual copper content found by analysis, which indicates an entire absence of segregation; also that the materials alloy very well up to a copper content of 7 per cent. This is in accord with the work of the earlier investigators.

Hardness.—The hardness tests are merely qualitative, being observations made in the machining, sawing and filing. In machining, the alloys with low percentages of copper worked very easily. The hardness increased with the increase of copper until at 5 to 7 per cent, while it was still possible to turn in the lathe, it was with some difficulty. There were the same evidences in the sawing and filing tests, the high copper being classed as extremely hard to saw. The authors intend to make a metallographic study to explain the hardness.

Tensile Strength Tests.—Of the bars cut from each rod for the tensile tests, an equal number were reserved for tests as forged and after annealing. In annealing, the samples were packed in a magnesia-lined graphite box and were heated in an electric resistor furnace. The temperature was brought up to 900° C. and held at this point for several hours, and several hours were needed for the slow cooling in the furnace. The test samples were approximately from 0.3 to 0.4 inches in diameter, with a free length of 2 inches. The diameter used in the calculations is the mean of several readings with micrometer calipers. The tests were made on a Riehle 100,000-lb. power-driven machine. The load was applied very slowly and the beam kept in balance. The yield point was obtained with dividers, and was taken at that point at which a perceptible permanent stretch had taken place. This was checked by the drop of the beam.

The summary of the results of these tests is given in plates I and II (page 528).

The measurements gave the yield point, the ultimate strength, the percentage of elongation in 2 inches and the percentage of reduction of area at fracture. The plates are plotted from the averages of the figures, and it is not to be expected, considering the many variables which might arise in tensile strength tests, that any series will give a simple curve. It is merely hoped to show the tendency of the increasing percentages of copper. The values of the yield point, ultimate strength, elongation and reduction of area are designed as points used in plotting the curves by the appropriate letters Y. U. E. and R.

Unannealed.—From the curves of Table I, it will be noted that the rise in the ultimate strength and the elastic limit is almost a linear function of the percentage of copper. The ultimate strength increases from 61,180 lb. per sq. in. at 0.1 per cent copper to 132,400 lb. at 7 per cent. The yield point rises from 52,580 to 122,900. There is a corresponding fall in the elongation from 28.5 per cent at 0.1 per cent copper to 4 per cent at 7 per cent copper. The reduction of area increases slightly from 69.2 per cent at 0.1 Cu to 72.1 per cent at 0.6 and 0.8 per cent Cu; from this point it falls to 7.3 per cent at 7 per cent of copper.

The results of these tests indicate a high tensile strength, which increases with the percentage of copper. The alloys are rather brittle, as indicated by the elongation and the reduction of area. Also, the elastic ratio (ratio of the elastic limit to the

ultimate strength) is large, varying from 0.86 at 0.1 per cent copper to 0.93 at 7 per cent Cu.

Annealed.—The results of annealing are given in plate II, and the effect is very marked, especially for the higher percentages of copper. There is greater consistency in the results, as is to be expected, and the points fall fairly well in line on the curves.

Up to 1 per cent copper there is a marked increase of the elastic limit and the ultimate strength with the additions of

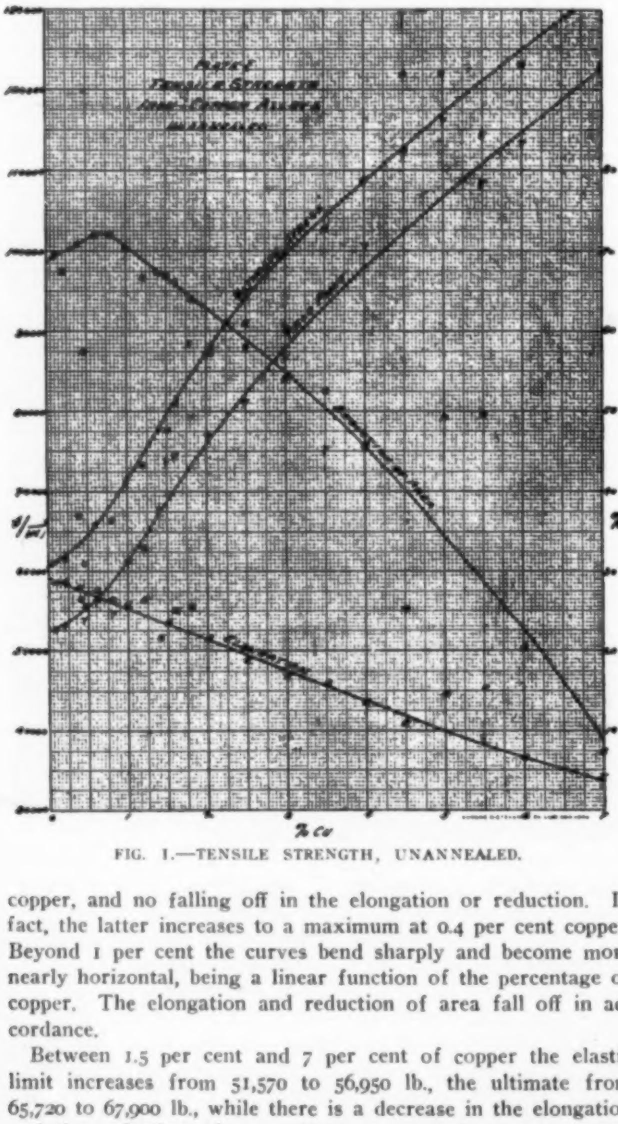


FIG. 1.—TENSILE STRENGTH, UNANNEALED.

copper, and no falling off in the elongation or reduction. In fact, the latter increases to a maximum at 0.4 per cent copper. Beyond 1 per cent the curves bend sharply and become more nearly horizontal, being a linear function of the percentage of copper. The elongation and reduction of area fall off in accordance.

Between 1.5 per cent and 7 per cent of copper the elastic limit increases from 51,570 to 56,950 lb., the ultimate from 65,720 to 67,900 lb., while there is a decrease in the elongation and the reduction of area. Between 0.1 and 1.5 per cent of copper the elastic limit rises from 35,570 to 51,580 lb., the ultimate strength from 54,050 to 65,720 lb., while the elongation and the reduction of area remain about the same. Breuil mentions the 4 per cent alloy as worthy of further study, and this is no doubt true, since he observes very high values. His figures agree well with those of the present authors. But, while Breuil lays particular stress on the 4 per cent alloy, the results of the present authors indicate the greatest value between 1 and 2 per cent for the annealed samples. The very sharp rise of the elastic limit and the ultimate strength at this percentage gives values but very little less than those for high copper content; also there is a removal from the region where the forging and welding properties are poorer with consequent uncertainties of result. Likewise, between 1 and 2 per cent the elastic limit and the reduction of area are very high.

It would hardly be advisable to work with 1 per cent of copper, since this is on the edge of the limit, where there is liable to be a fall to the lower values obtained with lower percentages of copper. At 1.5 per cent we are far enough removed so that the slight differences of composition to be met in practice would not bring the material into a dangerous region. Also, the elastic ratio of 0.78 is slightly lower than for the 4 per cent alloy, where it is 0.81.

The authors state that they would have considerable hesitation in bringing forward this point without a vast number of tests for confirmation, but for the fact that an observation of Breuil's results indicates the same condition.

Another fact to be noted in the tests of the authors is the marked difference between the unannealed and the annealed samples. It would indicate that there is a possible intermediate heat treatment which, not being so drastic in its effect as the long annealing of the authors, would give intermediate values, and thus approximate the nickel steels. This condition might be reached in commercial rolling where heavier masses of metal leave the material in a condition analagous to that resulting from a partial anneal.

To compare the copper-iron with the nickel alloys the authors quote Waddell's extensive investigations. In considering the use of nickel steel for bridge building, he mentions a steel with about 3.5 per cent nickel, carbon 0.38 per cent, the values for which may be taken as, elastic limit, 60,000 lb. per sq. in.; ultimate, 105,000 lb. per sq. in.; elastic ratio, from 0.55 to 0.60. These values are for sections as rolled without heat treatment and working at a somewhat low ductility, as shown by the figures 15 per cent for nickel steel, 27 per cent for carbon steel

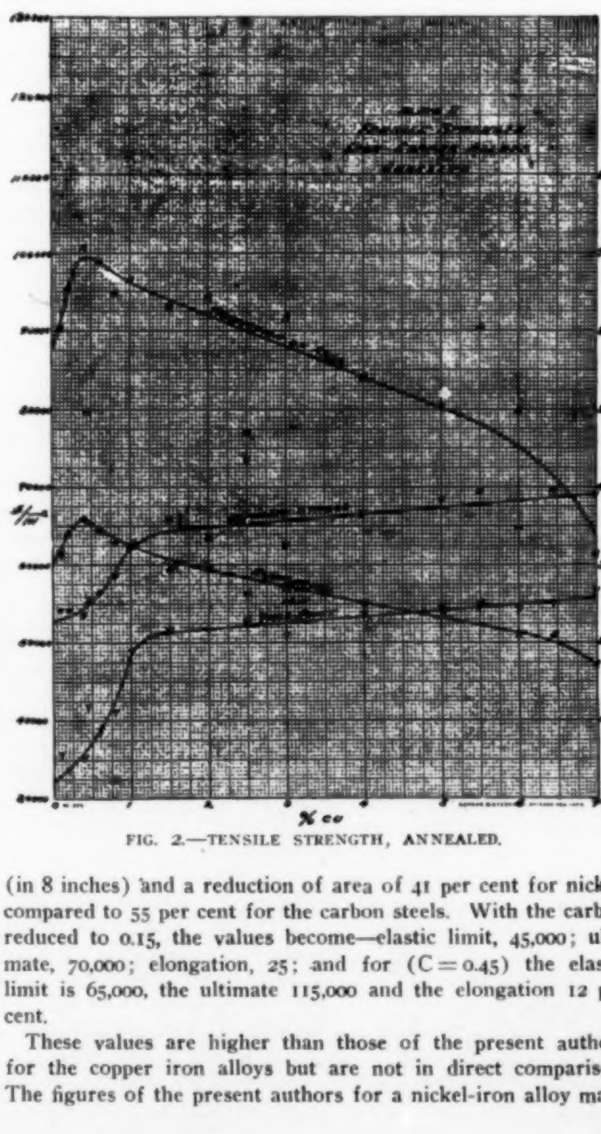


FIG. 2.—TENSILE STRENGTH, ANNEALED.

(in 8 inches) and a reduction of area of 41 per cent for nickel, compared to 55 per cent for the carbon steels. With the carbon reduced to 0.15, the values become—elastic limit, 45,000; ultimate, 70,000; elongation, 25; and for (C = 0.45) the elastic limit is 65,000, the ultimate 115,000 and the elongation 12 per cent.

These values are higher than those of the present authors for the copper iron alloys but are not in direct comparison. The figures of the present authors for a nickel-iron alloy made

under the same conditions as the copper-iron series are given in the following tables, where the 4 per cent nickel is compared with the 1.5 per cent and 4 per cent copper alloys. There is also given Hadfield's test of an alloy of 3.82 per cent nickel and carbon = 0.19 per cent (Inst. Civ. Eng., March 28, 1899).

	Elastic Limit.	Ultimate Strength.	Elastic Ratio.	Elongation Per Cent.	Reduction Area Per Cent.
UNANNEALED.					
4.00 Ni	67,000	76,000	0.88	28.5	68.6
1.50 Cu	73,920	77,300	0.95	23.5	66.9
4.00 Cu	105,560	108,640	0.97	13.5	45.6
3.82 Ni	62,720	82,800	0.76	30.0	54.0
ANNEALED.					
4.00 Ni	57,000	69,000	0.83	26.5	64.8
1.50 Cu	51,570	65,720	0.79	29.2	63.1
4.00 Cu	53,570	66,540	0.81	24.8	54.2
3.82 Ni	56,000	73,920	0.76	35.0	55.0

The above values for the nickel alloys are less than are commonly assigned to commercial materials where the carbon is a factor. The results are very comparable to those of the copper-iron series made under identical conditions.

Waddell, in his paper, shows that there is an economic advantage in the use of the nickel steels in comparison with the carbon steels ordinarily used, since their increased cost is more than offset by the less weight required, due to their increased strength. The results and comparisons of the present authors would indicate that the copper-iron alloys are also worthy of consideration and might be comparable to the nickel steels in use, even if the strength should not reach such high values as those of the nickel. A 1.5 per cent copper alloy is of promise, since the smaller percentage required and the lessened cost per pound of copper as compared with nickel would result in a lessened cost of construction, even if there is some increase in tonnage required because of the slight decreased strength per equal weight.

In the discussion which followed, Dr. J. W. Richards said that in metallurgical respects the paper of Professor Burgess and Mr. Aston was a very important paper. Much of our steel contains copper (from 0.5 to 0.7), and it has been claimed privately that the copper is not injurious, but rather beneficial. This has now been established by Professor Burgess.

Mr. Aldrich asked about the action of copper in high-carbon steels. Professor Burgess explained that his tests referred to low-carbon steels, the carbon being less than 0.1 per cent. Enough copper steels, containing more carbon, had, however, been made accidentally during the investigation, to make sure that in high-carbon steels copper is detrimental, causing brittleness.

But forging and heat-treatment has much to do with the resulting properties. As to corrosion, they had made very extended tests with a great many copper-iron alloys, which were subjected to various corrosive influences, but the results were not so promising as might have been expected.

Calcium Carbide.

A paper by Dr. M. DeKay Thompson, of the Massachusetts Institute of Technology, deals with the equilibrium pressure of carbon monoxide in the monovariant system consisting of this gas, lime, carbon and calcium carbide, with special reference to the recent paper of C. A. Hansen (this journal, October issue, p. 427). The object of Dr. Thompson's work was to measure the pressure of carbon monoxide in this system for a series of temperatures, from which both the free energy and the total energy or the heat from the reaction could be deduced.

The apparatus used was an Arsem furnace as described by Hansen. It was connected to that end of a syphon barometer which is usually open to the atmosphere, and to a Geryk pump. It was planned to place an Acheson graphite crucible filled with a mixture of lime, graphite and calcium carbide in the helix, heat to a definite temperature measured by a Wanner pyrometer, and read off the pressure on the mercury column. In order to approach the equilibrium from both sides, bottles for generating carbon monoxide from potassium ferrocyanide and concentrated sulphuric acid were connected to the furnace through two soda-lime bottles and a phosphorus pentoxide tube.

In some experiments only lime and carbon or calcium carbide were used, trusting to the reaction to produce the phases that were lacking.

The carbon screen ordinarily used to prevent too much loss by radiation was left out in experiments carried out below 1600° C. on account of the property carbon has of absorbing gases, and consequent uncertainty in the meaning of the pressure readings. The furnace was already evacuated to a pressure of less than a millimeter before beginning the experiment.

When making experiments with a temperature of 1500° C. and upwards, it was always found after each run that a white powder covered the inside walls of the furnace. This is due to the direct decomposition of the carbide according to the equation $CaC_2 = Ca + 2C$, and further combination of the liberated calcium according to the reaction $Ca + CO = CaO + C$. If this is so, the pressure of the carbon monoxide will be reduced below what it should be for equilibrium, and the constant readings will be purely accidental.

Dr. Thompson describes various experiments which show that calcium carbide is decomposed in a vacuum at 1692° C., forming metallic calcium, while in presence of carbon monoxide, the white powder is formed instead of metallic calcium, due to a reaction between calcium and carbon monoxide, which probably takes place as the calcium comes off in the form of vapor. The fact that carbon monoxide unites with calcium is also shown by the drop in pressure when the carbide and the gas are heated together and when at the same time the white powder is found inside the furnace after the run.

Dr. Thompson also shows how completely carbon monoxide can be removed by metallic calcium at a temperature of 1400° C., a pressure of 1 mm of monoxide being reduced to less than 0.1 mm when the temperature was raised from 1300° C. to 1400° C.

The conclusion is drawn that equilibrium conditions cannot be obtained quite so easily with this arrangement and that Hansen's measurements cannot correspond to equilibrium. The only sure way to get equilibrium is to approach it from both sides. To further prove that Mr. Hansen's results do not represent equilibrium, the author calculates on the basis of a formula of Van't Hoff the ratio of the pressure of carbon monoxide for 1800° and 1400° and finds theoretically a ratio of 840, while Hansen measurements gave 3.9.

The paper is summed up as follows: "It is shown experimentally that the equilibrium pressure of carbon monoxide cannot be obtained by heating lime, carbon and carbide or lime and carbon alone initially in a vacuum, on account of the decomposition of the carbide into calcium and carbon and the subsequent reaction of carbon monoxide and calcium. Hansen's results cannot, therefore, represent equilibrium." Dr. Thompson's researches will be continued.

In the discussion Mr. Hansen described his experiments and stated that he thought he had found a distinct indication of equilibrium; he reserved his further reply for publication in the *Transactions*.

Electric Smelting of Iron Ore.

A paper presented by Mr. E. R. Taylor, of Penn Yan, N. Y., pointed out that the necessity for large furnaces for the electric smelting of iron ores will be upon us in the very near future. It is often the case that plans that serve for small demonstrations are not very well adapted for large operations. In this connection Mr. Taylor's carbon bisulphide electric furnace, now in commercial operation, offers some suggestions that may be of use.

Fig. 1 with enlarged bottom shows this furnace with electrodes and broken carbons for their reinforcement. Several years' experience in the use of this means of prolonging the life and regulation of electrodes has demonstrated its great usefulness, and points to its value in furnaces of large size.

The new proposed furnace for smelting iron is shown in Figs. 2 and 3; the design is interesting as an endeavor is made to charge the ore and fuel separately and at the same time to make the incoming charge serve to conserve the heat by feeding the fine ore around the periphery of the furnace and subsequently forcing it towards and into the heat zone of the furnace.

As shown in Fig. 2, the electrodes are placed under arches which protect them from the descending material and permit their renewal when necessary. These arches and others protecting the feed screws for forcing the fine ore into the interior of the furnace serve to support the upper brick lining of the furnace. Fig. 2 shows a cylindrical construction resting on arches, through which charcoal or other form of carbon is fed to maintain a vertical column down to and between the main electrodes which is designed in part to prevent the ore from occupying that space and enabling it to form and be maintained as the weakest part of the electric circuit, that is, that portion which is between the main electrodes. Outside of the cylinder just described is a chamber "*w*" into which is fed coarse ore, and, if desired, fluxes. Outside of this again are shown the chambers "*k*" and "*y*", into which fine ore is fed; also fluxes, if desired.

Baffle plates "*p*" are interposed in the walls that form the chamber *k-y*, preferably of triangular shape, leaving a space below them so that carbonic acid gases can pass from the interior to an outer chamber, and in the passage come in contact with the descending fine ore, reducing more or less of it to the state of metal. More or less also of this ore in chamber *k-y* falls through openings under the baffle plates and mingles with the coarse ore in the sections *w*. This carries radiated

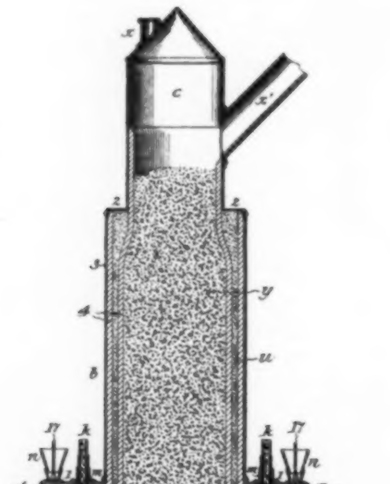


FIG. 1.—CARBON BISULPHIDE FURNACE.

heat towards the interior while its place is taken by cooler ore from above.

Electric motors are shown at *X*, on the outer periphery of the furnace-driving small fans, which return the carbonic acid gas to the interior of the furnace where it may be again reduced to the state of carbonic oxide, and made capable of reducing more ore to the metallic state.

Fig. 3 shows the hearth of the furnace, whose lining consists of carbon electrode, capable of being placed either in circuit with electrodes at the top of the furnace, or with the main electrodes at will. At one side is shown a spout connected with a tap hole for the removal of the molten metal, and in dotted lines directly in front at the back of the structure the tap hole for the removal of slag. It is quite likely that the hip or enlarged bottom (Fig. 1, bisulphide of carbon furnace) would be the better form for a furnace for this work. It is not necessary that the broken carbons should travel the whole distance from the top of the furnace to the electrode, and the hip form would offer better facilities for the removal of the electrodes.

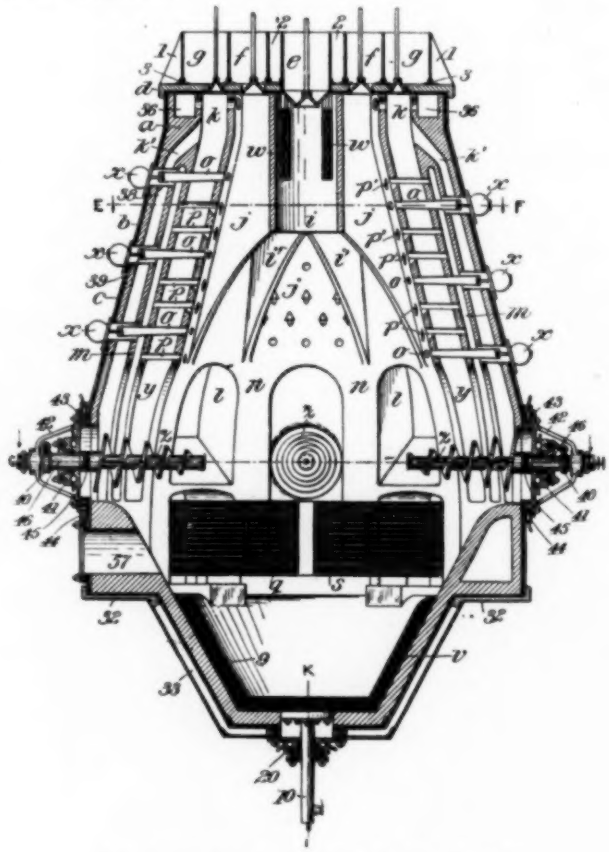


FIG. 2.—FURNACE FOR IRON-ORE REDUCTION.

The screws for forcing the ore forward are shown clearly in Fig. 2. These screws work in the outer and cooler portions of the fine ore and are not intended to be subjected to any considerable heat. They are hollow and may be connected with a blast of air when desired to change the working conditions of the furnace, for example to oxidize the charge to make it less conductive, or to burn out carbon when in excess. Fig. 2 also shows the column of charcoal maintaining itself down through the center of the shaft. Also the demarkation of the coarse and fine ore in their progress.

The discussion of Mr. Taylor's paper was opened by Mr. P. G. Salom, who asked for figures of the number of kw-hours required per ton of ore. Mr. Taylor had these figures not in mind; but he said that the consumption of power is comparatively low and a comparatively small amount of carbon is required, since the operation is relatively simple compared with the blast furnace, there being no large amount of nitrogen to be heated, etc. Mr. Hering remarked that the energy consumption depended to a large extent on the proportion of CO and CO_2 in the escaping gases.

Dr. Richards thought it would be only a few years until several electric-shaft furnaces would be in commercial operation. He did not like, however, Mr. Taylor's scheme of feeding fuel and ore separately, since the fine ore packs and the reducing gases cannot pass through it. In this latter criticism he was supported by Mr. C. A. Hansen, who referred to

some experiments on making ferrosilicon, in which he tried to determine the effect of fine grinding of the charge upon the uniformity of yield and rate of reaction. The charge consisted of scrap iron, silica and carbon, a charge largely used in commercial manufacture. The test apparatus used was the well-known Arsem vacuum furnace, connected to a pump of constant displacement. When the charge is heated and CO is generated by the reaction, the manometer reading, when constant, will obviously be proportional practically, to the reaction rate.

In one case, Mr. Hansen's charge was broken to pass a 1/8-in. square mesh, and the fines which passed through a 1/16-in. mesh were discarded. Manometer readings were taken at various temperatures. In another case the materials were all ground to extreme fineness, briquetted with a very dilute water-glass solution and baked to 960° C. A charge of

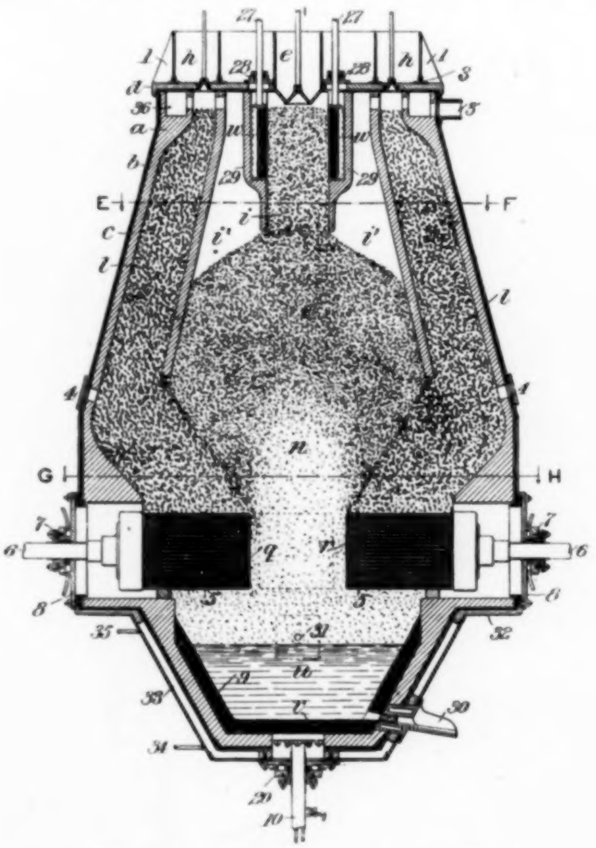


FIG. 3.—FURNACE FOR IRON-ORE REDUCTION.

the same weight as in the previous case was used and manometer readings were again taken at various temperatures. The results in the two cases were as follows:

Temperature deg. C.	CO Pressure Readings. Coarse charge.	Fine charge.
1400	0.4 mm	8 mm
1700	3. "	27 "
1900	5. "	60 "
2100	9. "	60 "

In other words the reaction rate which, at the lower temperature depends solely upon contact between solids, is enormously increased by increasing the contact area. Making use of these results Mr. Hansen ran a briquetted charge into a furnace, the charge volume of which was scarcely over 1 cu. ft. (magnetite, however, replacing the scrap iron) at a power input of 100 kw, turned out 50 per cent alloy from this small furnace at slightly more than 2 kw hours per pound, and practically of the composition determined by the charge. The furnace did not get excessively hot; there was very little fume. At this rate the commercial 1000-kw furnaces could absorb nearly 5000-kw. Obviously the losses per unit output are enormously decreased by this procedure, and it becomes merely a case of balancing the cost of grinding and briquetting against the cost of power. In the case of ferrosilicon, so long as no one objects to the fumes, the balance is probably in favor of not grinding charge. Mr. Hansen believes, however, firmly that much is to be gained by bringing the solid reagents into as intimate a contact as possible, in this case, in the case of iron ore reduction and in all similar cases.

Calcium; Anode Effect.

A paper by Dr. Francis C. Frary and Mr. W. L. Bodger, of the University of Minnesota, dealt with the preparation of calcium in the laboratory. A valuable summary is first given of former work done by various experimenters. They mention, as the key to success, the method of drawing out the calcium when deposited in form of a rod attached to the cathode (so as to prevent it from redissolving). This is the method used at Bitterfeld, Germany, where calcium is produced on a commercial scale.

The authors used the arrangement of Tucker and Whitney, which they modified in some respects. They had troubles with the anode effect. This "anode effect" is a peculiar and interesting phenomenon, apparently first mentioned by Bunsen, who complains of the interruption of the current, soon after starting the electrolysis, caused, as he thought, by the formation of a layer of either silicon or lime on one of the electrodes. Similar effects have been observed by others.

There have been several theories to account for this phenomenon. In the electrolysis of cryolite, it seems to be due to an improvisement of the bath and is remedied by adding more alumina. (Seligman, this journal, Vol. 7, p. 148.) It has been described as a variety of the spheroidal state, which it certainly resembles in appearance. Borchers ascribes it to excessive current density at the anode, while Willner believes it is due to a layer of silica which he considers would be deposited at the anode if the melt contained a silicate in solution.

With the apparatus of Tucker & Whitney, in several electrolyses of strontium and barium chlorides, each of several hours' duration, the authors never observed the phenomenon, while in the same apparatus they sometimes had much trouble in the electrolysis of calcium chloride. The chloride used was Merck's C. P. anhydrous; analysis of a 6 gm. sample showed the presence of no weighable amount of silica; 0.002 per cent should easily have been detected if present. The anode was always Acheson graphite, and as the inner surface was only very slowly and slightly attacked it seems improbable that the pound or more of the electrolyte could have been seriously contaminated by the traces of silica contained in it, especially as calcium was continually being produced and fresh chloride added.

All the experience of the authors points to the anodic current density as being the important factor in the production of this effect. It is quite possible that the presence of excessive amounts of silica might be a contributing case; the formation of a film of silica over part of the anode raising the current density on the rest above the critical point. The detailed explanation of the phenomenon seems to the authors to be as follows:

Under any particular set of circumstances, for any given electrolyte, there is a critical anodic current density, above which the gas will be evolved fast enough so that its bubbles unite into a sheet of gas, through which the current must pass by means of arcs. This, of course, by reducing the current, reduces the current density; but the power consumed is nearly double, and all of the increase, and more, is expended in this layer of gas, heating it to a very high temperature, and thus bringing about the appearance of the spheroidal state.

Some of the electrolyte may be volatilized, too. But as a rule in using this apparatus at as low a temperature as possible (in order to obtain good yield) only part of the crucible is

"open," i. e., in contact with fused electrolyte, the rest being frozen. Now, when the anode effect takes place, the "open" surface of the crucible, and the electrolyte next it, are heated very rapidly, hence the adjoining electrolyte in contact with the crucible is thawed and the "open" or active surface of the anode (crucible) is increased. But at the higher temperature now prevailing at the anode, the critical current-density is much lower, hence quite a little of the congealed electrolyte must thaw out before the critical point is passed and the layer of gas breaks. This again allows quiet electrolysis to take place, and on a larger anode surface than at first, hence below the critical density. The melt now cools slowly, gradually decreasing the active anode surface until the effect again appears.

If the current density is the controlling factor, it ought to be possible, by increasing this at any point, to cause the effect to occur. This was easily accomplished; all that was necessary was to momentarily swing the cathode toward the active anode surface, thus altering the lines of current distribution, and the effect could generally be produced at once.

There remain two peculiarities of the effect to be discussed: (1) That it was never noticed with a new crucible, or, as noted by Willner, could be prevented by changing the anode; (2) that if with the same apparatus, the current used was raised to 175 amp or 180 amp, no trace of an anode effect was found. The first is explained by the fact that the crucibles when made did not have a smooth interior surface, and the irregularities, extending into the electrolyte, prevented the formation of the film of gas. As the crucible was used, these were gradually worn off, and the surface became noticeably smoother, allowing the film to form. With the higher current, the temperature of the whole electrolyte was much higher; in fact, almost all of the upper portion of the crucible was "open," and the critical current density was never reached.

Some melting point determinations were made. Two samples of "pure" calcium chloride were tested, giving 766° C. and 755° C. The latter sample contained 0.66 per cent CaO and 0.15 per cent $CaCO_3$.

By adding successive portions of oxide, the authors were able to reduce the freezing point to 705°, where the analysis showed CaO, 6.26 per cent, $CaCO_3$, 3.38 per cent. With more oxide, they began to get a partial freezing at about 770°, while the rest of the melt did not freeze till 705° to 720°, indicating the presence of eutectics.

Electro-Cementizing.

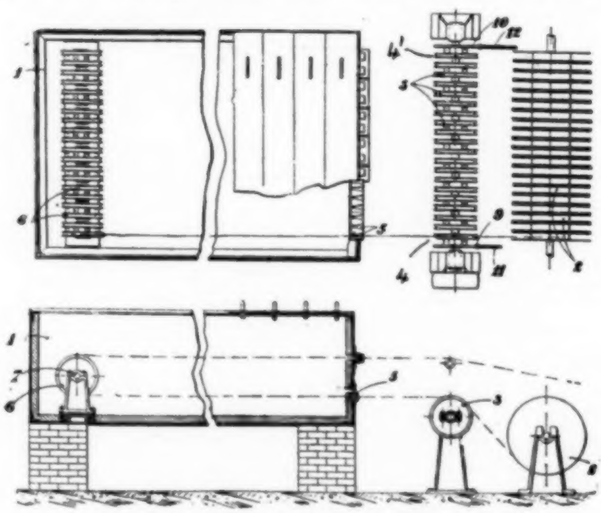
A paper by Mr. ALFRED SANG, of Paris, France, describes first the usual hot process of galvanizing iron or steel wire for fencing, barb-wire, etc., by the wet method. There are five operations: annealing, cleaning, fluxing, coating and wiping. The hot process is not a simple one and an expert wire galvanizer is a valuable specialist; it only appears simple and advantageous as compared to more recent processes, because there are two generations of experience back of it. There exists now a demand for something better than the present grade of galvanized wire, and the "electro-cementizing process" is believed to be better. It is soon to be tried on a small commercial scale.

The claims to attention possessed by this process are its comparative simplicity, the fact that it lends itself to scientific control and the qualitiy of the product. It can hardly equal the low costs for hot galvanizing under ordinary conditions.

The principle involved in this new process, which is called "electro-cementizing"—cementizing being the process of depositing metals by cementation, of which sherardizing is a form—is the method of heating by electricity, the heat being directly applied to the articles by using them as resistances. On the very face of it, it is only applicable in practice to articles of small cross-section, such as wires and strips, although in theory it may be applicable to larger goods, and if carried out on a very important scale could undoubtedly be applied to thin sheets and tubes.

Referring to the diagram: the coating chamber or furnace (1) is built of iron plates and lined with refractory material as used in zinc smelting furnaces; it is filled from the top with a mixture of crushed coal and oxide of zinc. The wire comes off the reels (2) and passes over and around brass contact sheaves (3) which are equal in number to the strands of wire which the furnace will treat at one time, and are mounted tight on a common shaft from which they are insulated by non-conducting bushings. This shaft, by revolving, leads the wires and relieves the tension on them. The single sheaves at each end of the shaft (4, 4') are connected through the proper rheostat to the poles of a suitable transformer supplying alternating current at a low tension which may be varied within certain limits. The intermediate sheaves are paired by means of common hubs so that the current may pass freely from one to the other in each pair.

The wires now pass between the hinged aprons or flaps (5) and into the lower part of the furnace, then over another series



PLANT FOR ELECTRO-CEMENTIZING.

of sheaves (6) inside and at the rear end of the furnace, these sheaves being similar in every respect to the double sheaves on the outside, but staggered in relation to them, by which is meant that the near sheave of each outside pair is in line with the far sheave of each inside pair; the wires then return through the upper part of the furnace and through a second set of hinged flaps, to the take-up frame which would, if shown in the drawing, stand to the right of the paying-out reels.

When all the strands of the wire are in place and connected, therefore, in series, the current will pass zig-zag wise in and out of the furnace and a wire resistance of considerable length will thus be afforded. The entire system forms a resistance grid on a very large scale.

As the heating-up is necessarily rapid and as no useful purpose can be served by maintaining the full temperature once it has permeated the wire, it is probable that a very short furnace will suffice.

The details of the operation may be described as follows: The wire is quickly brought to a bright cherry-red, at which temperature all grease is volatilized, scale or rust is reduced by the carbon and occluded gases are driven out; at the same time, the zinc oxide in immedate contact is reduced, and, as vapor, soaks into the "pores" of the metal, which are well opened by the heating, and condenses on the surface as the heat drops. As the wire returns through the upper part of the furnace it cools down slowly from a temperature considerably above its recalescence point, so that it is annealed. With low-carbon steels an excess temperature of 200° or 300° is not likely to seriously affect the quality of the wire. The coating is of the color of freshly electro-deposited silver. The quality of the product is mostly due to the alloy of zinc and iron; the author

claims that iron which has absorbed an almost infinitesimal amount of zinc, by being exposed to zinc vapor in a reducing atmosphere, is most difficult to corrode and resists a solution of hydrochloric acid in a most remarkable manner.

The oxide and finely divided carbon form a non-conducting mass, and the heat emanating from the wires will accumulate in the furnace until a constant temperature, not far below the reduction point of the oxide, will be reached; this will greatly reduce the amount of current required to operate the process. After the operation is under way, the resistance of the hot wires will be much greater than that of the cold wire.

Compared with sherardizing, the electro-cementizing process has a better heat efficiency. While the cost of the furnace will surely exceed that of the hot process, at least until the furnace has reached its constant temperature, the costs of installation, maintenance and depreciation, taken in one with the other, will probably be lower than for the hot plant, the cost of the zinc will be much less, standing at about 3½ cents on a 5-cent spelter market with less waste, and the labor cost should be little, if at all, in excess of what it is at present; the wire will run more slowly, but there will be a compensating increase in the number of strands. Whether practical difficulties will arise with regard to the temperature of the wire and possible breaking of the wire inside the furnace, will be decided by trying the process on a commercial scale.

Two resolutions proposed by Mr. Taylor were adopted. One commended the work of the New York State Water Supply Commission and recommended an amendment to the Constitution of the State of New York, which will enable the commission to cut timber and make reservoirs in such reserve lands belonging to the State as the Commission may recommend.

The second resolution viewed "with alarm the possibility of any private interests securing advance control of water rights, coal and other mines of valuable minerals in the Public Lands of the United States, and of the several States," and urged legislation to meet such possible exigencies. The work of the National Conservation Commission and of the Inland Waterways Commission was recommended.

A vote of thanks to all who made the meeting successful was then adopted.

The next meeting will be held in spring, in Pittsburgh, Pa.

In the following we give a complete alphabetical list of all members and guests who registered:

Mr. and Mrs. Paul Abbe, New York City; Dr. and Mrs. E. G. Acheson, Niagara Falls, N. Y.; Miss Acheson, Niagara Falls, N. Y.; Chas. E. Acker, New York City; G. P. Adamson, Easton, Pa.; Mr. and Mrs. L. Addicks, Elizabeth, N. J.; C. H. Aldrich, Elizabeth, N. J.; Thos. B. Allen, Niagara Falls, N. Y.; R. S. Allyn, New York City; Henry E. Armstrong, London, England; Mr. and Mrs. W. C. Arsem, Schenectady, N. Y.; J. W. Aylsworth, East Orange, N. J.; Dr. Bachofner; Dr. and Mrs. L. H. Baekeland, Yonkers, N. Y.; F. Bailey, Perth Amboy, N. J.; Mr. and Mrs. H. B. Baldwin, Newark, N. J.; Harry Barker, New York City; Mr. Barmvoller, New York City; Dr. and Mrs. Chas. Baskerville, New York City; W. H. Bassett, Torrington, Conn.; L. Batter, New York City; Mrs. Battin, New York City; Edward R. Berry, Lynn, Mass.; P. A. Boeck, Worcester, Mass.; L. W. Bosart, Jr., Staten Island, N. Y.; Walter Bowman, New York City; George Breed, Philadelphia, Pa.; A. A. Breneman, New York City; C. A. Browne, J. K. Bryan, C. L. Bryden, Scranton, Pa.; Leon H. Buck, New York City; H. Buel, C. F. Burgess, Madison, Wis.; Wm. Campbell, New York City; Henry S. Carhart, Ann Arbor, Mich.; Mr. and Mrs. C. F. Carrier, Jr., New York City; C. R. Cary, New York City; Clinton F. Chance, Oldbury, England; Mrs. C. F. Chandler, New York City; W. B. Chapman, New York City; W. C. Chapman, New York City; W. F. Chem, R. B. Chillas, Jr., Cleveland, Ohio; V. P. Christoffauer, Wm. M. Clark, New York City; C. S. Clifford, Mr. and Mrs. W. R. Clymer, Cleveland, Ohio; Mrs. H. B. Cobleigh, New York City; M. P. Cohn, Toronto, Canada; Mr. and Mrs. H. B. Coho, New York City; W. P. Coho, H. R. Connell, Pittsburg, Pa.; C. R. Cory, Philadelphia, Pa.; F. D. Crane, Montclair, N. J.; E. E. F. Creighton, Schenectady, N. Y.; J. S. Crider, Cleveland, Ohio; T. E. Crossmay, New York City; Mrs. J. Davila, S. W. Davis, Jr., Indian Head, N. J.; J. B. Devlin, R. A. Dodd, East Orange, N. J.; M. L. Dolt, Dr. and Mrs. Chas. A. Doremus, New York City; J. E. Dowd, Wm. Dreyfus, New York City; Mr. and Mrs. G. Drobegg, Brooklyn, N. Y.; H. Du Bois, O. E. Dunlap, Niagara Falls, N. Y.; Edw. Durant, New York City; Myron C. Durkee, New York City; Mrs. A. S. Dwight, New York City; Mr. and Mrs. M. G. Eckendorf, New York City; Mr. and Mrs. Arthur H. Elliott, New York City; Horace H. Emrick, Maurer, N. J.; V. Englehardt, Charlottenberg, Germany; Ernest F. Eurich, New York City; Albert H. Fay, New York City; B. G. Fernberg, Colin G. Fink, Schenectady, N. Y.; F. W. Fink, F. A. J. FitzGerald, Niagara Falls, N. Y.; Richard Fleming, Westfield, N. J.; Milton W. Franklin, Schenectady, N. Y.; Richard H. Gaines, New York City; Dr. and Mrs. Albert F. Ganz, Hoboken, N. J.; Mr. and Mrs. J. Geissler, New York City; W. T. Gibbs, Buckingham, Ont.; A. E. Gibbs, Wyandotte, Mich.; Miss Mabel Gibbs, H. N. Gilbert, Jacob S. Goldbaum, Philadelphia, Pa.; J. H. Goodwin, East Orange, N. J.; V. E. Goodwin, Schenectady, N. Y.; J. H. Granbery, New York City; Mr. and Mrs. C. A. Graves, Brooklyn, N. Y.; W. M. Grosvenor, New York City; George G. Grower, Ansonia, Conn.; G. W. Gurley, George H. Guy, New York City; Wm. J. Hammer, New York City; Chas. W. Hammond, Pleasant Plains, N. Y.; Miss Hattie S. Hammond, Pleasant Plains, N. Y.; John F. Hammond, Pleasant Plains, N. Y.; W. A. Hamor, Rutherford, N. J.; Mrs. Thomas J. Handforth, New York City; C. A. Hansen, Schenectady, N. Y.; Vigo Hansen, New York City; S. C. Harrit, New York City; Raymond Haskeel, Tompkinsville, N. Y.; Mr. and Mrs. Jacob Hasslacher, New York City; Albert A. Heimrod, New York City; Mr. and Mrs. F. Hemingway, New York City; Percival Henderson, El Paso, Texas; Dr. and Mrs. C. H. Hennig, Brooklyn, N. Y.; Mr. and Mrs. C. I. B. Hennig, Haskell, N. J.; Carl Hering, Philadelphia, Pa.; Edwin F. Hicks, Philadelphia, Pa.; R. S. Hitt, New York City; Harael A. Hogel, Denver, Col.; William E. Hogel, Denver, Col.; W. E. Holland, East Orange, N. J.; Maurice L. Holt, South Bethlehem, Pa.; Edward H. Holtorf, Brooklyn, N. Y.; Wm. A. Horton, Mr. and Mrs. Henry Howard, Brookline, Mass.; G. F. D. Hoye, New York City; Mr. and Mrs. Walter R. Ingalls, New York City; A. Innerhofer, Buffalo, N. Y.; Mr. and Mrs. Alois von Isakovics, Monticello, N. Y.; Frederick A. Johnston, Prince Bay, N. Y.; Wilbur H. Johnston, Stapleton, N. Y.; Farel L. Jouard, New York City; Mr. and Mrs. C. M. Joyce, Arlington, N. J.; A. L. Kamerer, Robert Kann, C. Powell Karr, New York City; Parker H. Kemble, Brooklyn, N. Y.; P. Kemery, Pittsburgh, Pa.; Mr. and Mrs. O. A. Kenyon, New York City; Miss Kenyon, New York City; Edward F. Kern, New York City; V. R. King, Wood Ridge, N. Y.; F. Klepetko, Mr. and Mrs. J. Mason Knox, Schenectady, N. Y.; Theo. Koch, Wm. Koehler, Cleveland, Ohio; Milton H. Kohn, New York City; V. F. Krauss, L. J. Krom, P. H. Kuechel, Brooklyn, N. Y.; Dr. and Mrs. Geo. F. Kunz, New York City; John Langton, New York City; Mr. and Mrs. Wm. J. Lansley, New York City; C. Le Boutillier, High Bridge, N. J.; Walter G. Levison, Brooklyn, N. Y.; Arthur G. Levy, New York City; F. A. Lidbury, Niagara Falls, N. Y.; C. B. Lihme, La Salle, Ill.; Chas. F. Lindsey, Schenectady, N. Y.; Dr. and Mrs. Morris Loeb, New York City; E. G. Loomis, New York City; H. W. F. Lorenz, New York City; H. Loveridge, Henry J. Lucke, New York City; Mrs. M. Macnaughton, East Orange, N. J.; F. Maeulen, Prince Bay, N. Y.; Otto Mantius, Philadelphia, Pa.; T. C. Martin, New York City; Edmund O. Mays, New York City; Mr. and Mrs. F. J. Maywald, New York City; A. S. McAllister, New York City; F. H. McBerty, New York City; Dr. and Mrs. Chas. F. McKenna, New York City; H. J. McRae, L. B. Miller, East Orange, N. J.; W. H. Miller, Orange, N. J.; H. S. Miner, Gloucester City, N. J.; A. Monrath, New York City; Henry G. Morris, Philadelphia, Pa.; Mr. and Mrs. J. T. Morrow, New York City; W. R. Mott, Madison, Wis.; C. W. Moulton, Poughkeepsie, N. Y.; R. S. Moulton, Poughkeepsie, N. Y.; Ralph E. Myers, East Orange, N. J.; H. Neustaedter, Jersey City, N. J.; Thomas A. Nevins, New York City; Dr. and Mrs. Wm. H. Nichols, New York City; R. H. Nieder, J. E. Noeggerath, Schnectady, N. Y.; G. M. Nonnen, R. S. Orr, G. E. Page, Pittsburg, Pa.; T. J. Parker, New York City; Chas. L. Parsons, Durham, N. H.; J. C. Pennie, Herbert Philipp, Perth Amboy, N. J.; General John Pitman, Orange, N. J.; J. R. Pitman, Orange, N. J.; Chr. Edw. Porst, A. F. Porter, Haskell, N. J.; J. A. Powders, Dr. Quincke, Leverhusen, Germany; W. J. Rich, J. W. Richards, South Bethlehem, Pa.; Francis W. Richards, New York City; Miss Erma B. Robbins, New York City; A. G. Rodgers, Niagara Falls, N. Y.; Dr. and Mrs. E. F. Roeber, New York City; C. M. Rogers, F. W. Roller, New York City; Thomas Rowlands, Niagara Falls, Canada; Louis Ruhl, New York City; D. B. Rushmore, S. S. Sadtler, Philadelphia, Pa.; Pedro G. Salom, Philadelphia, Pa.; John Santon, New York City; L. E. Saunders, Niagara Falls, N. Y.; Walter M. Saunders, Providence, R. I.; M. F. Schank, Brooklyn, N. Y.; Carl Schleusener Hochst a/m, Germany; C. M. Edward Schroeder, Rutherford, N. J.; Mr. and Mrs. F. F. Schuetz, New York City; R. C. Schüpphaus, Arthur P. Scott, Schenectady, N. Y.; R. W. Seabury, J. A. Seede, Schenectady, N. Y.; Dr. and Mrs. C. H. Sharp, White Plains, N. Y.; S. P. Sharples, Boston, Mass.; R. H. Sherry, New York City; S. DeV. Shipley, Stamford, Conn.; W. R. Simpson, New York City; A. L. Smith, East Orange, N. J.; Edgar F. Smith, Philadelphia, Pa.; Edmond F. Smith, Niagara Falls, N. Y.; John Smith, New York City; Wm. A. Smith, Niagara Falls, N. Y.; N. Clyde Snook, Philadelphia, Pa.; R. C. Snowden, Ossining, N. Y.; W. L. Spalding, Buffalo, N. Y.; Mr. and Mrs. E. A. Sperry, New York City; Mr. and Mrs. H. J. Steher, New York City; B. S. Stephenson, R. Stevenson, Marcus Stine, New York City; Mr. and Mrs. E. D. Stone, Bema, Tenn.; Mr. and Mrs. I. F. Stone, New York City; B. Stoughton, A. H. Strong, New York City; Dr. and Mrs. J. Takamine, New York City; Chas. E. Taylor, Penn Yan, N. Y.; Mr. and Mrs. Edward R. Taylor, Penn Yan, N. Y.; Miss Edith Taylor, Penn Yan, N. Y.; Dr. and Mrs. J. E. Teeple, New York City; E. L. Tessio, Dr. and Mrs. C. J. Thatcher, New York City; B. F. Thomas, Chattanooga, Tenn.; Stephen A. Thomas, New York City; Mr. and Mrs. John Thompson, New York City; R. Tiedlke, Hochst a/m, Germany; Mr. and Mrs. Maximilian Toch, New York City; F. J. Tone, Niagara Falls, N. Y.; Clinton P. Townsend, Washington, D. C.; Guy Trott, East Orange, N. J.; S. A. Tucker, New York City; W. H. Van Winchel, Midland, Mich.; Anthony Victorin, New York City; L. D. Vorce, Detroit, Mich.; Montgomery Waddell, New York City; Dr. and Mrs. Leonard Waldo, Plainfield, N. J.; Miss Anne R. Waldo, Plainfield, N. J.; Miss Ruth M. Waldo, Plainfield, N. J.; A. L. Walker, New York City; Chas. R. Walker, Newburgh, N. Y.; J. W. Wallace, Brooklyn, N. Y.; H. B. Warren, New Jersey; W. D. Weaver, New York City; Wm. S. Weedon, Wilmington, Del.; C. A. Weeks, Philadelphia, Pa.; A. E. Weiner, E. Weintraub, Lynn, Mass.; G. Werlün, Philadelphia, Pa.; David Wesson, Montclair, N. J.; Edward Weston, Newark, N. J.; Mr. and Mrs. C. G. White, Haskell, N. J.; S. E. Whiting, Cambridge, Mass.; W. R. Whitney, Schnectady, N. Y.; Dr. and Mrs. F. G. Wiechmann, New York City; H. W. Wiley, Washington, D. C.; Wm. Wilke, Buffalo, N. Y.; J. Lainson Wills, New York City; C. H. Wilson, W. E. Winship, New York City; Alfred A. Wohlauer, New York City; A. H. Wohlauer, Townsend Wolcott, New York City; Eugene A. Woodman, New York City; Albert Wurth, Orange, N. J.; Rowland L. Young, Pittsburg, Pa.; Mr. and Mrs. J. A. Yunck, South Orange, N. J.; Edward Zaremba, Chicago, Ill.; F. Zimmerman, Newark, N. J.

Retirement of Mr. Kirchhoff from "Iron Age."—Through the retirement, just announced, of Mr. Charles Kirchhoff from active business, after having disposed of his interest in *Iron Age*, the engineering press of this country loses one of its most able, most influential, and most distinguished editors. Mr. Kirchhoff graduated from the School of Mines of Clausthal, Germany, in 1874. His connection with *Iron Age* began in 1878. Since 1889 he has been the editor-in-chief.

Notes on Electrochemistry and Metallurgy in Great Britain.

(*From Our Special Correspondent.*)

The Institute of Metals.

Sir William White presided at the autumn meeting of the Institute of Metals at Manchester, on Oct. 14 and 15, in the hall of the Municipal School of Technology. In his address he said it was evident that there was need of a society to treat with the non-ferrous metals; and to show the necessity for the formation of the Institute he mentioned that whereas the number of members when the first meeting was held at Birmingham last year was 240, on July 1 this year there were 487 members, and more had been admitted since then.

Mr. E. A. Edwards read the first paper on "The Constitution and Properties of the Aluminium-Copper-Tin Alloys," by himself and Mr. J. H. Andrew (which was abstracted in our November issue, page 493).

Dr. H. C. H. Carpenter opened the discussion and said that an enormous amount of work must have been done for the production of the equilibrium diagrams of the ternary alloys. The diagram No. 2 necessitated the making of above 450 alloys. A fact of much scientific interest which had resulted was that tin was totally insoluble in many alloys and separated from them. With aluminium at its present price that fact might have a useful commercial application in the extraction of tin from residues which were not otherwise worth treating commercially. The authors, unfortunately, had not dealt with any large number of alloys having commercial interest.

Mr. Sinclair said that in a few investigations in aluminium alloys he had demonstrated the fact that alloys of aluminium and copper lose less in weight in seawater than other alloys; and, forming galvanic couples with them and other metals, he was astonished to discover that an alloy of 90 per cent copper with 10 per cent of aluminium lost nothing in weight.

Mr. J. Brentnall remarked that great difficulty was encountered in making castings of manganese bronze to prevent leakage under pressure. This caused him to turn his attention to alloys of aluminium and tin containing equal parts of each, on account of their peculiar behavior with regard to corrosion. The addition of copper up to about 10 per cent seemed to prevent corrosive action with these, but a further addition did not check the action to a corresponding degree. The addition of zinc to a tin-aluminium alloy largely increased corrosion, and with 95 per cent of zinc to 5 per cent of tin-aluminium the action was so intense that 250 c.c. of hydrogen were collected in half an hour.

Dr. Desch said it was noteworthy that the method of systematic quenching from different temperatures adopted by the authors was introduced by English metallurgists, Mr. Heycock and Mr. Neville, several years ago. The only one of the author's conclusions which he was inclined to dissent from was that a definite compound, Cu_3Al, would separate out. He thought that that compound, if it really existed, was stable only at lower temperatures. But the statement that that compound, Cu_3Al, was homogeneous at 550° C. and at 900° C., and yet broke up at intermediate temperatures was of high scientific interest because it varied from previously known facts and vitally affected the theory of metallic solid solutions.

Mr. Hudson said the gamma phase destroyed the utility of the alloys, and it was most important that the point at which the brittle phase appeared should be determined.

Sir William White considered that many interesting points were raised by the paper, and he regretted the absence of Dr. Rosenhain, who was making investigations for the alloys research committee of the Institute of Mechanical Engineers. The results would be very shortly communicated to that Institution, and would be found to be of great interest.

Dr. Rosenhain wrote to express his disappointment that the paper expressed mostly statements of results instead of data which would have been of great value. Should the authors' results require modification, the absence of data would reduce the value of the paper as an assistance to subsequent investigations.

A paper by Mr. E. L. Rhead on "Some Causes of the Corrosion of Copper and Brass," followed. (It was abstracted on page 493 of our November issue.)

Sir Gerard Muntz said that condenser tubes seldom pitted on the steam side, and when that did occur it was almost always due to the use of bad oil. Tubes pitted mostly on the lower side, because naturally the deposit fell there, and the deposit caused the trouble. Pitting in lines arose chiefly from continuous deposits lying in the tube in conjunction with the spills on the inside surfaces, caused by adhesion of particles of the cores in casting, which were elongated as the result of drawing. The author suggested that nodules of copper were occasionally present in tubes, but these where really places where the zinc had been removed and the copper left. In almost every case the deposits were due to impurities in the circulating water, and in all such cases the corrosive action was caused by the formation of galvanic couples between the zinc and the carbon or the iron. Corrosion also resulted from the decomposition of air and gases when overheating was consequent on too slow circulation. Trouble had also arisen from bad formation or situation of the water intake causing the introduction of much free air, and in such a case alteration of the intake had totally removed the trouble. Some of the tubes returned to his firm as defective had been found to be almost filled with shrimps and seaweed. With regard to the corrosion of Muntz metal—sheathing, bolts and under-water fittings—he could state that this mischief began to appear simultaneously with the use of electrolytic copper in 1888, when his firm made a very close inquiry, the result of which showed that corrosion was due, firstly, to the use of electrolytic copper, and, secondly, to the use of inferior varnish for fastening the sheathing. Smelted copper and Stockholm tar only ought to be used; other materials resulted in the formation of galvanic couples.

Mr. Bengough said that the electrolytic theory of corrosion was now accepted, and appeared to indicate how corrosion might be prevented. Hard material was generally electropositive to soft material, and this fact explained the results Mr. Rhead obtained in his tests with ferric chloride, as well as the copper enrichments near the edges of the plates. He agreed with Sir Gerard Muntz that these were not deposits of copper, but were spaces where the zinc had been dissolved out.

Mr. Sinclair thought that stray currents through the water pipes and condenser set up electrolysis. He had suggested as a remedy that the whole of the condenser should form a complete electric circuit.

Second Day's Papers.

Prof. T. Turner and Mr. M. Thornton Murray presented a paper on "The Copper-Zinc Alloys" (abstracted elsewhere in the Synopsis in this issue).

The discussion was opened by Mr. Bengough, who considered that as the curve of total shrinkage varied to a great extent for different alloys, and also for different sizes of castings, that curve must prove of very great practical value. Tubular results might, perhaps, have been better for the workshop. He considered that the similarity between the results of the "Brinnel test" and the tensile results quoted in the fourth report of the alloys research committee was worth attention.

Dr. Desch did not think that the authors' paper proved that a real expansion occurred during solidification; indeed, there appeared to be some evidence that there was contraction. Growth of crystals caused a thrust which might account for the apparent expansion, but this was a question of scientific interest only. To the practical brass founder it did not matter whether there were a true expansion or molecular action.

Mr. Vaughan Hughes described the paper as one of the most valuable of its kind which had been produced for some years.

Mr. Rhead suggested that microscopic examination might determine the true nature of the expansion.

Sir William White said that whatever might be the real explanation of the facts stated by the authors, the paper was admittedly one of the most notable which had been published for a long time.

Dr. Rosenhain wrote to say that he had some hesitation in accepting Professor Turner's extensometer readings as regarded changes in volume during solidification. The portion of the paper which dealt with actual observations of expansion constituted a most valuable addition to our knowledge of such alloys.

The next paper, on "The Elastic Breakdown of Non-Ferrous Metals," was presented by Mr. C. A. M. Smith. (It is abstracted in the Synopsis elsewhere in this issue.)

Sir Gerard Muntz led the discussion and commented on Mr. Smith's statement as to the want of uniformity in the specimens. In the case of non-ferrous metals that was one of the greatest difficulties. It was not easy to get concordant results with processes apparently identical. More was known about iron and steel, and with those metals there was not the same difficulty in complying with the stipulated test conditions. Heat treatment and other manufacturing processes gave rise to various questions which were constantly being investigated in their works, and he had also sent specimens of materials to their scientific members with the view of eliciting further knowledge of the effect of various processes on copper.

Mr. Parker gave his opinion that the sphingometer was not necessary nor suitable for commercial work. He preferred the Unwin extensometer. He deprecated the use of wedge grips for holding specimens, and was of opinion that, for round tests, screw nuts and screw grips with spherical seats should be used. He considered that the stress-set and stress-strain curves should accompany research reports. Such curves were of the highest importance to designers of modern high-speed machinery. The best definition of "elastic limit," for engineering work, would probably be the stress per square inch producing a permanent set of 0.001 in. on a 2-in. length.

Sir William White appealed to the members to supply Mr. Smith with materials to enable him to continue his investigations.

Professor Smith, in the course of his reply, admitted that his work had been greatly impeded by want of uniformity in the specimens of copper. As to trouble arising from vibration with the sphingometer, there was no difficulty in making the required corrections where vibration existed, but, of course, if perfect accuracy were desired, vibration must be absent.

Corrosion in Boilers.

The *Journal* of the Society of Chemical Industry recently mentioned a noteworthy case of corrosion in a stand-by boiler at a London power house. The action had been evident for a long time, and continued attempts to stop it by the use of caustic soda were fruitless. Scientific investigations traced its cause to the presence of manganese sulphide in the steel, which sulphide by oxidation had formed sulphuric acid. The acid being behind a film of rust, the corrosion continued, although the boiler water was alkaline. There were many blisters—some having a diameter of 3 cm—on the inside of the boiler, and it was apparent that the oxygen requisite to transform the sulphide into acid diffused through the blisters at a greater rate than the alkali in the water. The addition of sodic arsenite was found to remedy the mischief.

London, October, 1909.

Platinum.—According to the U. S. Geological Survey statistics, platinum is produced in this country only as a by-product in placer-gold mining in Oregon and California. The output in 1908 was 750 troy ounces, valued at $14,250. The yearly importations from Russia during the last three years have ranged from 4,237 lb. to 11,494 lb. ($1,095,754 to $3,601,120).

SYNOPSIS OF PERIODICAL LITERATURE

Iron and Steel.

While a full account of the recent London meeting of the Iron and Steel Institute was given in our last issue, page 487, with abstracts of all the papers presented, we give herewith some additional notes on two particularly interesting papers.

Electric Smelting of Iron Ore.—Mr. E. J. Ljungberg, of Falun, Sweden, described at the recent meeting of the Iron and Steel Institute the new shaft furnace of the Electrometall Company at Donnarfvet, constructed by Messrs. Grönwall & Lindblad (see our June issue, page 250; October, 420 and pages 489, 491 of this issue). The report gives the result of 1903 hours running of this furnace, during which it produced 280 tons of crude iron containing all the way from 3.09 per cent down to 0.95 per cent of carbon. The product with less than 2 per cent of carbon, produced in a liquid state by direct reduction of iron ore, is, indeed, a new commercial product; it is not pig iron, as that term is ordinarily understood. We propose for it the name *"pig steel"* (German, *Rohstahl"*; French, *"fonte d'acier."—Reviewer*).

In the run described, the consumption of materials and power per metric ton of product was as follows:

Ore	1380	kilos.
Lime	86	"
Coke	146	"
Charcoal	207	"
Electrodes, effectively used	9	"
Electrodes, wasted ends	14	"
Power	0.492	hp-year.

The escaping gases were low in temperature, carried the steam from the moisture of the charges, and contained 8 per cent to 41 per cent CO^2 and 40 per cent to 61 per cent of CO. They were free from nitrogen. It is calculated that 30 per cent of the whole energy of the current was lost by radiation and in cooling water, and attempts are being made to reduce these losses. The reaction of reduction, according to these analyses, is probably

$$4\,Fe^2O^3 + 9\,C = 6\,CO + 3\,CO^2 + 8\,Fe,$$

which is a better utilization of the carbon than has previously been obtained and which gives promise of the ratio 1 CO to 1 CO^2 (predicted as possible by Prof. J. W. Richards, this journal, June, 1909, page 253) being ultimately attained.

Ljungberg concludes his article by the statement that the problem of the electrical reduction of iron ore can be regarded as "technically solved."

In the discussion, it transpired that the constructors of this furnace have contracted to erect three of large size at Sault Ste. Marie, Canada, which will be in operation about the middle of 1910.

"Growth" of Cast Iron in Heating.—Mr. Outerbridge, of Philadelphia, first studied systematically the phenomenon of cast iron increasing in volume by repeated heatings, and Professors Rugan and Carpenter reported to the Iron and Steel Institute the results of their study of the same subject.

Taking a gray cast iron, no growth was observed at 600°, but this result is faulty, since cast-iron valves are known to increase in size at 366° in superheated steam. The heating at 600° was not prolonged sufficiently to get the effect. Two hours' heating at 650° produced a slight expansion, became greater in three hours. At 675° the rate of growth was eight times as rapid as at 650°. Maximum growth was attained by heating three hours at 730°, no greater expansion being obtained at 860°, nor by 17 hours' heating at 730°. After 99 heatings and coolings the cast irons tested (containing 0.96 per cent to 1.13 per cent silicon and 3.14 per cent to 3.48 per cent carbon) increased in volume 35.2 per cent to 37.5 per cent, and at the same time 7.86 per cent to 8.60 per cent in weight. This increase in weight had not been observed by Mr. Outerbridge. The cause of the growth was studied microscopically and found

to be the passage of the gases of the furnace (CO and CO^2) between the plates of graphite and the iron, oxidizing in these slits the silicon in the iron at the boundaries of the crystals, producing growth by the disintegration of the surface of these crystals and their pressure upon the graphite plates. The increase in weight is due to the absorption of oxygen and perhaps also of carbon. On reheating, the gases penetrate further into the metal, because of the avenues opened up by the previous heating. After many heatings the graphite is partly oxidized away, all the iron silicide in solid solution in the iron has been oxidized and disintegrated, and some iron has been oxidized as well. White irons do not thus grow, and where the repeated heatings and coolings tend to destroy cast iron it should be white instead of grey, and will then even shrink slightly on repeated heating if not high in carbon.

That the furnace gases cause the growth was very neatly proved by repeatedly heating some of the specimens in a vacuum when the growth did not take place.

Copper.

Standard Specifications.—In the London Engineering of Sept 17 we find a note on the report of the Copper Committee of the International Congress for Testing Materials, by its president, Prof. Leon Guillet, Paris, entitled "On Standard Specifications for the Purchase of Copper." In it replies were given by members to a number of questions which had been asked with reference to the committee's work and the specifications dealing with the manufacture and inspection of copper. This report gave an abstract of the specifications in force in Great Britain, France, Germany, Austria, Italy and Belgium. In regard to Great Britain, Messrs. Glazebrook and Tomlinson, the British members, stated that the specifications of the Engineering Standards Committee were much appreciated by the trade, and gave satisfaction; no modification appeared to them necessary. Meetings were held annually, in the course of which the question of modification or revision was considered. One Austrian delegate, a copper manufacturer, had remarked that the allowance on thickness and weight up to 3 per cent, which was granted, appeared to be sufficient for all copper material except wide plates, for the manufacture of fire boxes. The largest rolls, 900 mm (35½ in.) and over in diameter, used for rolling wide plates, might occasionally become concave to a slight extent, probably up to ¾ mm (0.029 in.), so that a wide plate might be 1½ mm to 2 mm (0.059 in. to 0.078 in.) thicker in the center than at the sides, and it was at the sides that the plates were measured. Some of the plates, therefore, were heavier than they should be theoretically. The Austrian manufacturers endeavored to obtain an allowance ranging from 3 to 6 per cent for plates ranging in width from 2.3 m (7 ft. 6½ in.) and under up to 3.2 m (10 ft. 6 in.). Another Austrian delegate, an inspector of railways, thought that the purchaser should not be called upon to pay for an unnecessary weight of copper, and the allowance of 3 per cent for wide plates has its advocates. Manufacturers should put down convex rolls for manufacturing such plates.

The question of impurities in copper, and their action in various proportions, was also dealt with; but this point, as well as that concerning the physical tests, had not been entered into with sufficient detail, owing to the short time the committee had at its disposal. It was hoped that a complete agreement would shortly be reached, and that a detailed report on a standard specification for the purchase of copper would be ready for the following Congress.

At a recent meeting of the members forming the Copper Committee, the British members desired to maintain the conditions of the British Standards Specification. Tensile tests for copper were maintained, with a maximum of 22 kg per square millimeter (14 tons per square inch). No final agreement had been reached in regard to elongation, nor in regard to annealing temperature, speed of tensile test, and shape of test-specimen. No final agreement had been reached either in the matter of tests by chemical analyses. The details would be given in a later report.

Zinc.

Technical Assay of Zinc.—In a paper presented at the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. H. W. Greenwood and Dr. F. J. Brislee discussed the relative value and accuracy of the various analytical methods for the determination of zinc and also the gathering together of the more important references to the analytical chemistry of zinc in both British and foreign literature. As a volumetric method they prefer Schaffner's on the grounds of its accuracy, definite nature of endpoint of reaction and general applicability. The gravimetric estimation of zinc is not recommended by them as a technical method, but when necessary they prefer the estimation as pyrophosphate for moderate quantities and a modified calcium zincate method for small quantities. Electrolytic methods are not, in the opinion of the authors, to be recommended for technical work. Good results can be obtained by several methods, but the deposit is difficult to deal with and for that reason volumetric methods have been found much more advantageous. A number of methods for the assay of zinc ores and alloys are dealt with, some of which the authors believe have not hitherto been published, notably a method for the estimation of zinc and aluminium in alloys of these metals, by the weight of hydrogen evolved on solution of the alloy in hydrochloric acid. The authors hope to continue their work on other non-ferrous metals. (From advance sheets.)

Copper-Zinc Alloys—Prof. T. Turner and Mr. M. Thornton Murray presented a paper on the solidification phenomena of copper-zinc alloys at the recent Manchester meeting of the (Brit.) Institute of Metals. For some years past investigations have been in progress in the University of Birmingham on the changes in volume which occur when metals pass from the fluid state to the temperature of the air. Important results have been obtained in the case of cast iron which has been proved to have three definite expansions while the solid metal is cooling, these arrests corresponding to particular temperatures, and the separation of certain ingredients. The experiments have now been continued in a study of the alloys of copper and zinc which, as the brasses, constitute the most important of the industrial alloys. The hitherto unrecorded fact is published that with certain percentage of zinc and copper the metal when poured into the mold does not immediately begin to contract, owing to the cooling, as might be anticipated, but for a short time actually expands. This expansion, no doubt, accounts for the excellent impression of the mold, and the sharp lines, which are met with in certain brass castings. Ore alloys with about 15 per cent of copper expands in a most remarkable manner, so much so indeed that after the metal has finally cooled and shrunk in the mold the bar is as long as the pattern from which it was cast. It is curious to note, however, that some of the alloys in the series do not expand at all when solidifying, these being the brass with 60 per cent of copper, known as Muntz metal, and that with 40 per cent of copper, which is a hard white brittle alloy, and probably a definite chemical compound. The authors have also determined the hardness of these alloys and find that the 40 per cent alloy is the hardest of the series, and that it is actually much harder than mild steel. The experiments are likely to have an important theoretical as well as practical bearing, as it is believed expansometer tests will be more largely used in future as an aid to the determination of the constitution of alloys.

Miscellaneous.

Solders.—At the recent Manchester meeting of the (Brit.) Institute of Metals, Mr. C. O. Bannister and Mr. H. J. Tabor presented a paper containing the results of experiments, carried out with a view to obtain exact information on the effect of small quantities of impurities on the surface appearance of solders. It is well known that sales of solder are often influenced by appearance rather than by analysis, and it is

important that when cast in the form of strips the solder should have a white, bright surface with a furrow and be free from rough patches, spots, pits or pimples. The effect of antimony, which has been previously noted by Parry, is worked out fairly full, the effect of casting under different conditions being noted, in addition to the effect of varying quantities of antimony. The results confirm the statement that tinman's solder containing 2 per cent antimony, 46 per cent tin and 53 per cent lead is superior in appearance to that of the alloy consisting wholly of lead and tin in equal proportions and that with 3 per cent antimony spots appear on the surface.

Microscopic examination of these alloys shows that in the case of the 3 per cent antimony alloy cubical crystals are seen on the prepared sections after polishing and etching. These crystals probably consist of the compound SnSb and are not found in the alloys containing 1 and 2 per cent antimony. The segregation of these crystals to the top of the alloy seems to cause the spots. Solders containing small quantities of copper give good surfaces, but with a tendency to spot, while larger quantities, 0.5 per cent and upward, give dull, flat and crystalline surfaces. Solders containing small quantities of silver have a peculiar white crystalline appearance. Zinc is a most detrimental metal to have present in solders, minute quantities as 0.005 per cent making the surface crystalline, while 0.1 per cent and over give extremely uneven and inferior surface appearances.

Elastic Breakdown of Non-Ferrous Metals.—A paper on this subject was presented by Prof. C. Alfred M. Smith at the recent Manchester meeting of the (Brit.) Institute of Metals. He said that some three years ago he commenced to attack the problem of the cause of elastic breakdown of materials used in engineering work. Various researches and investigations published by him showed that the solution of the problem as regards mild steel was different to that generally accepted by engineers in England and on the Continent. Elastic failure of mild steel always took place, under any system of loading, by reason of the sheer stress. Having proved that, he wished to find out whether all other ductile materials followed the same law. He could only say that they appeared to do so, he could produce no exact experimental evidence. The reason was that copper, aluminium, Muntz metal and various other materials appeared to be much less homogeneous than mild steel. In a word, the result of his researches proved that, so far as the elastic properties of the material were concerned, mild steel was much more reliable than other materials. He produced the results of a large number of tests upon various materials and described in detail the instrument which he has invented for measuring small strains and which is known as the sphingometer. It is an exceedingly simple device and measures extensions of length of the astonishingly small amount of a quarter of a millionth part of an inch. It has been especially useful in testing work and will measure torque strains as well as extensions of length. Among the interesting facts which Professor Smith's experiments reveal are the peculiar fracture of aluminium and the effect of low temperature heat treatment on the non-ferrous metals. (From advance sheets.)

Melting Points.—The *Amer. Jour. of Science* of November contains two papers by W. P. White on work done in the Geophysical Laboratory in Washington on melting-point determinations. The first paper treats of melting phenomena in general. The second paper describes the furnace technic used in melting-point determinations. The results of the first paper are summed up as follows:

Actual melting and freezing-point curves are nearly always oblique—that is, they show not the constant temperature called for by elementary theory, but instead, an interval within which the temperature continuously rises or falls. The prime cause of obliquity in melting curves is the obliquity of the melting itself, due to impurity. The true melting point is the high end of the oblique melting interval. The melting hysteresis of some very viscous substances (mostly compounds of boron and silicon) is also an occasional (and then serious) cause of obliquity. A number of causes of obliquity lie in the experimental determination of the behavior of the melting and freezing substance. The determination of a melting curve necessarily involves two factors: temperature rise and heat supply; the latter depends on the temperature difference of furnace and melting charge; if this varies, the curve is distorted in a way striking but easy to correct. The most common and conspicuous example is where the furnace temperature is allowed to rise or fall continuously, while the substance, melting or freezing, remains nearly stationary. The freezing point, coming at the beginning (in time) of the interval, where temperature distribution in the charge is relatively uniform, is easier to observe than the melting point, but is inadmissible in substances where undercooling is marked. The melting point coming at the end (in time) of the interval, is liable, where stirring is not practiced, to obliquities resulting from uneven temperature distribution: First, due to the inevitable temperature difference between inside and outside of the charge, troublesome with large charges, negligible with small. Second, due to various irregularities in heat flow, less with narrow charges and small thermoelements, hardly ever over a degree or two. Third, due to conduction of heat down the thermoelement, also less with narrow charges and small thermoelements, for which it is usually negligible, but possibly amounting to several degrees with inclosed elements. Electric conductivity in the melt produces an error in the reading of bare thermoelements, thus far negligible in small charges of salts. Contaminated elements, besides reading false, read so as to increase obliquity. Differentiation and diathermancy of the charge probably increase obliquity. Meltings have been made above 800° agreeing with each other to 0.05°. In most cases an experimental obliquity remains of from 0.5° to 1.5° (at high temperatures).

In the second paper the author gives a description of the furnace, crucibles, thermoelements used in melting-point determinations and then deals with some particular methods for the determination of melting points, melting points of viscous substances, quasi-calorimetric determinations, small thermal effects, and residual meltings. The results are summed up as follows: Platinum-resistance furnaces of simple construction provide complete control of the temperature for melting-point work up to 1600° C. Where uniformity of temperature throughout the working chamber is important special modifications are necessary. Small charges (2.5 grams) give very sharp melting points, are economical of material, and permit of convenient manipulation. A number of advantages result from the use of a second thermoelement, which is made to give directly the furnace temperature about the charge. The measurement and regulation of the heat supply from the furnace are factors of great importance in accurate melting-point determination. Methods of treating and insulating thermoelements and of avoiding the effects of contamination have been developed by the author, suited to various conditions and kinds of work. The melting points of very viscous substances, showing hysteresis, can be determined easily and effectively by very slow heating and occasional examination outside the furnace. The approximate determination of latent heats of fusion directly from melting curves is possible by measurements of the furnace temperature, but is encumbered by several hitherto undetermined sources of error. The attainment of an accuracy greater than 10 per cent (about 10 calories in many silicates) accordingly requires special apparatus and procedure. The smaller latent heats of inversion can usually be determined to one or two calories with no other apparatus than the two thermoelements. For determining faint or sluggish thermal effects rapid rates of heating and the utmost precision in furnace regulation and temperature measurement are needed. The accurate location of eutectics by thermal means requires the detection of small residues of the component in excess.

RECENT METALLURGICAL AND ELECTRO-CHEMICAL PATENTS

Iron and Steel.

Dry Blast.—The dry-blast process of Mr. James Gayley has undoubtedly been the most important advance in the metallurgy of iron in recent years. Though it has at once yielded savings, far beyond what had been expected or what had been thought by many to be possible, it is still being improved and perfected by its ingenious inventor. The dry-blast systems which have been installed in plants previously constructed were so arranged that the blowing engines were in proximity to the blast furnaces, while the refrigerating apparatus or dry-air plant has been placed at considerable distance from the blowing engines, owing to its size, and the filling of the space near the furnace by various other buildings appurtenant to the furnace. In these plants, therefore, a long pipe or conduit extends from the air-drying apparatus to the blowing engines, and it has not been recognized in the past that any disadvantage resulted. Mr. Gayley has found, however, that this long pipe causes a considerable variation in the weight of the air fed to the blowing engines. These pipes or conduits have been made of comparatively thin sheet iron or steel, and as they are subjected to the heating rays of the sun by day and to air of a cooler temperature at night, the air passing through them reached the blowing engine at varying temperatures, and consequently varying weights per unit of volume. On the other hand, it is easy to see that the air should not only have a substantially uniform moisture content, but should be of substantially uniform temperature, as it enters the blowing engine, in order that the blowing engine, and consequently the blast furnace or converter shall receive a supply of air which is not only uniform as regards its moisture content, but also uniform as to weight. The air is, of course, measured by the blowing engine as it passes through the blowing engine, and unless the air received by the blowing engine is uniform in temperature the blowing engine will deliver non-uniform weights of air, and consequently the metallurgical process will not be uniform. The blowing engine can only measure the air as to volume, while uniformity as to content of moisture, and as to weight, can only be obtained by treatment of the air before it is supplied to the blowing engine. In carrying out this discovery when dry-air apparatus is applied to existing plants, where the air-drying apparatus is remote from the blowing engine, Mr. Gayley therefore now proposes to jacket or otherwise protect the air conduit to the blowing engine in order to preserve a substantially uniform temperature of the air therein, and thus supply air of substantially uniform weight, as well as substantially uniform moisture content, to the blowing engine. (935,628, Sept. 28, 1909.)

Thermit Process.—In the well-known aluminothermic process for the welding of metals and similar uses thermit, which consists of a mixture of finely divided aluminium and ferric oxide, is employed. The reaction between the metal and oxide results in the reduction of the iron oxide and the oxidation of the aluminium. The heat generated by this reaction is very great and has found useful application in a number of ways. It has been tried to use silicon as a substitute for aluminium in this reaction according to the equation $3\,Si + 2\,Fe_2O_3 = 4\,Fe + 3\,SiO_2$, but the reaction has been stated to be too slow for practical applications. Mr. Frank J. Tone, of the Carborundum Company (who has reduced the production of metallic silicon to a commercial process on the large scale) claims, however, now that a mixture of silicon and oxygen compounds is capable of the self-propagating reaction which distinguishes the aluminothermic process. He uses a mixture "of finely divided metallic silicon and some oxide, as, for instance, ferric oxide, preferably in the proportion of 84 parts of silicon and 320 parts of ferric oxide." Ignition is obtained by the use of a small quantity of one of the unstable compounds, such as potassium chlorate or sodium peroxide, mixed with part of the silicon. The mixture of silicon with these unstable oxides may be ignited with a match. (939,930, Nov. 9, 1909.)

In a second patent of the same inventor this process is modified in order to increase the energy density. If a mixture is made of silicon and a "highly oxidized unstable oxygen compound," like potassium chlorate $3\,Si + 2\,KClO_3 = 3\,SiO_2 + 2\,KCl$, the reaction is so violent as to be almost explosive in character, and one which cannot be made use of in practical work. But by replacing only a part of the ferric oxide with "a highly oxidized" oxygen compound, there is no explosion or tendency of the mixture to be thrown out of the containing vessel, and the energy density of the mass is greatly increased. In practice, Mr. Tone has found that by taking one part of a mixture of silicon and potassium chlorate made up in accordance with the last equation and three parts of a mixture of silicon and ferric oxide made up in accordance with the equation $3\,Si + 2\,Fe_2O_3 = 4\,Fe + 3\,SiO_2$ he gets very satisfactory results. The reaction, after being initiated, proceeds without violence and "the heat generated is more intense." (939,570, Nov. 9, 1909.)

Calcium-Silicon Alloy for Steel Refining.—The calcium-silicon alloy is an excellent refining agent for steel. Dr. Hans Goldschmidt, who has paid much attention to this alloy (see his article in our Vol. VI, page 244), had recently patented a process of making such an alloy, which was described in our June issue, page 284. This alloy contains about one-third of calcium and two-thirds of silicon. To enrich this alloy much more in silicon, Dr. Hans Goldschmidt and Dr. O. Weil now propose the following process: They melt the alloy down with iron under a protecting layer of chloride of calcium, whereby the iron, under formation of ferrosilicon, combines with such a quantity of silicon that an alloy will be formed containing about two-thirds of calcium and one-third of silicon. This alloy is of less specific weight than the ferrosilicon, so that the latter sinks down to the bottom and may be easily separated. A good result is obtained by employing 1 kg of calcium-silicon alloy and 1 kg to 2 kg of iron. In the same way the alloys of other alkaline earth metals with silicon may be enriched by melting them together with iron. (938,758, Nov. 2, 1909.)

Titanium-Silicon-Carbon Ferro.—For steel refining Mr. Fred. M. Becket recommends the use of an alloy containing chiefly titanium, iron, silica and carbon. A typical analysis is: titanium, 33.70 per cent; iron, 43.69; silicon, 14.23; carbon, 8.32; aluminium, 0.08; calcium, trace. The alloy in a suitable state of subdivision is added to the molten metal at the time of casting. The titanium is believed to act chiefly upon the occluded nitrogen and the silicon upon the hydrogen and dissolved oxides. The alloy is prepared in the electric furnace by either of the following methods: (1) by reducing by carbon in an electric furnace a charge containing oxides of titanium and silicon; (2) by reducing oxide of titanium by carbon in an electric furnace, ferrosilicon or silicon being incorporated with the charge or added to the bath. The carbon is usually employed in substantially the proportion required to unite with the oxygen of the oxides of the charge. The process is rendered continuous by adding fresh portions of the charge and removing the products from time to time. The patent is assigned to the Electro Metallurgical Company. (940,665, Nov. 23, 1909.)

Reduction of Carbon in Castings.—Mr. W. Rübel patents a process for quickly reducing the carbon content in pig iron for use for small castings and states that a modification of the process may be employed to reduce the carbon content in finished castings, without the necessity of annealing afterward. The process depends on treatment of the molten pig iron with fused sodium hydroxide (melting point, 750° C.). When the molten pig iron, containing about 3.5 per cent of carbon, meets the molten sodium hydroxide, double decomposition takes place, in the course of which the sodium hydroxide is transformed into carbonate of sodium, thereby withdrawing the carbon from the

iron. In this reaction hydrogen is liberated and is burned. The high degree of heat so generated aids the formation of pearlite. If finished castings containing 3.5 per cent C. are to be treated they are put into a retort or a muffle containing fused sodium hydroxide or potassium hydroxide, in such quantity that the castings are completely covered by the molten hydroxide. The temperature of the retort or muffle is then raised to 1100° C. or 1500° C., and, at this temperature, decarburization proceeds very rapidly. The retort or muffle is provided with a safety valve capable of withstanding a pressure of about two atmospheres. If the gas pressure in the retort exceeds that amount, the valve opens and the gas passes through a cooling coil into a receptacle filled with a solution of ammonia, whereby the sodium liberated in the process is dissolved. The gases not absorbed by the ammonia are carried back to the furnace and serve to heat the same. It is important to obtain a pressure of about two atmospheres, as this promotes the reaction. If, for example, the decarburization is to be carried out to the extent of reducing 3.5 per cent to about 1.5 per cent, at the temperatures given, heating for about two hours is required. At the end of this time a valve provided on the retort or muffle is opened and the excess of sodium hydroxide is run off. Then the retort is permitted to cool gradually and the castings are removed. For the complete decarburization of castings up to about 20 mm thickness, about six hours is required. "Iron decarburized by the above method has a crystalline lustrous fracture like ingot-iron cast from crucibles. By changing the time and temperatures employed decarburization may be so regulated that the finished product, after annealing, is equal to fine casting in steel of corresponding quality." (935,234, Sept. 28.)

Deoxidizing Slags.—Aluminium has long been known to be an excellent deoxidizing agent for use in steel refining. Only small quantities are used, however, in each case, because the aluminium burns with the oxygen in the steel bath to form a slag which is separated with difficulty. If, however, the aluminium is passed through the metal after the oxides have been extracted, there is no formation of clay, and the aluminium, if properly introduced, ascends to the surface of the metal and acts upon the layer of slag from below. This method is employed by Mr. O. Thallner for the deoxidation of the slag. Quantities of aluminium are introduced into the metal bath below the slag at intervals; they are in excess of that required to deoxidize the metal. In this way a sufficient quantity of aluminium eventually rises to the top of the metal and burns in its course through the slag, thereby deoxidizing the slag. The aluminium rising through the deoxidized steel to the surface of the metal bath, spreads in a layer between this metal bath and then rises through the slag, so that the deoxidation proceeds from below. The completion of the deoxidation is indicated by the white color of the slag. "This white slag is well adapted to allow the passage therethrough of sulphur. This last feature is one of considerable importance, as the molten bath of steel can be freed of its content of sulphur subsequent to the deoxidation." (936,382, Oct. 12, 1909.)

Permanent Magnet Steel.—Mr. S. E. Gertler patents a steel for permanent magnets, comprising tungsten 5.25 per cent, carbon 0.65 per cent, silicon 0.15 per cent, manganese 0.25 per cent, chromium 0.20 per cent, sulphur and phosphorus 0.02 per cent or less, aluminium 2.50 per cent, and iron to an amount providing 100 per cent in all. (936,530, Oct. 12.)

Electric Steel Furnace.—The well-known modified induction furnace of Messrs. Hermann Röchling and Wilhelm Rodenhauser has been so often described in detail in this journal that a brief reference to the patent which has just been granted to the inventors for this furnace must suffice here. (939,095, Nov. 2, 1909.)

Iron-Ore Reduction Furnace.—Elsewhere in this issue will be found an American Electrochemical Society paper by Mr. Edward R. Taylor (the inventor of the electric carbon-bisulphide furnace, which is in successful operation on a large scale as well known to our readers). This paper contains an illustrated description of his new electric furnace for the reduction of iron ore. Two patents have just been granted to Mr. Taylor for this furnace; one, the process patent has 20 claims; the other, the apparatus patent, has 60 claims. (938,352 and 938,351, Oct. 26.)

Aluminium and Iron.—The abstract of a recent patent of Mr. A. G. Betts, which will be found below under Aluminium, should be interesting to iron metallurgists.

Aluminium.

Production of Aluminium.—Only one process, that of Hall & Héroult, is used the world over for the production of aluminium and has been very successful, in spite of the recent slump in the market price. That there is, however, much space for a cheaper process, starting from cheaper raw materials, there can be no doubt. Mr. Anson G. Betts proposes the following: Iron ore and aluminium ore, e.g., bauxite or kaolin, are charged with fuel in a blast furnace similar to an iron blast furnace, differing from it, however, in action, in that a higher temperature is used in the smelting section of the furnace. The higher temperature may be produced by using a more highly heated blast, but especially well by blowing the furnace with air, from which some of the nitrogen has been removed; such a gaseous mixture may be produced by liquefaction and fractionation of air. In an iron furnace little or no aluminium is reduced with the iron, but a fair amount of silicon is formed. In smelting for iron-aluminium alloys practically all the silicon present is reduced; and as silica is always a constituent of both iron and aluminium ores, the product is not ferro-aluminium, but iron-aluminium-silicon. The most readily oxidized, sulphurized, chloridized, etc., metal of the iron-aluminium-silicon, aluminium may be removed as pure aluminium compound by treatment with suitable oxidizing, sulphurizing and chloridizing reagents. Thus treatment of iron-aluminium-silicon with silica at high temperatures gives a slag of pure alumina and ferrosilicon.

$$Fe_xSi_yAl_4 + 3\,SiO_2 = Fe_xSi_{y+3} + 2\,Al_2O_3,$$

or treatment of iron-aluminium-silicon with iron ore gives, at high temperatures, pure fused alumina and ferrosilicon, provided the iron ore is free from lime, magnesia, etc.

The aluminium alloy is then treated with iron sulphide, both being used in fused condition directly after tapping from their respective smelting furnaces, giving the reaction

$$2\,Al + 3\,FeS = Al_2S_3 + 3\,Fe.$$

"The aluminium sulphide is more readily and cheaply reduced to aluminium than the oxide is" and iron sulphide is available in large quantities, permitting the recovery of both iron and sulphur. Although iron sulphide is available in a fairly pure condition, Mr. Betts prefers to run the sulphide through a furnace with suitable additions to flux off the gangue, for the double purpose of getting rid of the gangue and for heating the sulphide. When pyrite is smelted, he contemplates being able to increase the yield of sulphide by adding iron oxide to the charge to carry out these reactions:

$$FeS_2 = FeS + S$$
$$FeO + S + CO = FeS + CO_2,$$

that is to say, the first reaction is the decomposition of the pyrites by heat into ferrous sulphide and sulphur. The liberated sulphur acting on iron oxide in presence of carbon or carbon monoxide produces a further quantity of iron sulphide.

In smelting the aluminium alloy with the sulphide, the aluminium is used in excess so that the end products of the reaction are aluminium sulphide, substantially free from the sulphides of more readily reducible metals, and an alloy still containing some aluminium, which aluminium may be removed readily by oxidizing agents if desired. To insure the reaction taking place to be as complete as possible, it is preferred to carry out the reaction in two stages. The alloy is first treated

with an insufficient quantity of iron sulphide, etc., to react with the aluminium present, resulting in practically pure aluminium sulphide.

The alloy which will still contain considerable aluminium is then treated with excess of iron sulphide, forming a matte containing both iron and aluminium sulphide, which matte is then used alone or together with fresh iron sulphide in the next treatment of aluminium alloy. Finally, the aluminium sulphide is reduced by electrolysis into aluminium and sulphur. (938,-634, Nov. 2, 1909.)

Precious Metals.

Electro-Cyanide Amalgamation Process.—A process, patented by Mr. John R. Parks, of Spokane, Wash., proceeds as follows:

The properly finely powdered ore is delivered to a launder where it meets the cyanide solution and is conducted into the first electro-cyanide pan of a series of tandem pans with gradually increasing levels, so that the contents of each pan will overflow into the next succeeding pan. The inventor allows, "according to the composition of the ore, from ½ lb. to 20 lb. of cyanide of potassium, 5 lb. to 7 lb. of common salt, 1 lb. to 3 lb. of lime, and 1 ton of water to pass into the first cyanide pan with each dry ton of powdered ore. To this is added from 3 oz. to 500 oz. of mercury." After the crushed or powdered ore enters the first pan of the tandem series, each pan holding approximately from 5 tons to 7½ tons of dry ore, it passes from pan to pan of the series, every portion of it undergoing treatment for an average time of from 8 to 12 hours, according to the rate of feed into the first pan. Each of the tandem pans is provided with a horizontal revolving cast-iron disk formed of two or more annular sections and mounted upon insulated bearings, whereby the disk may be used as the anode in an electrolytic circuit. Immediately below the lower face of this revolving disk is a copper plate, which forms the cathode, upon which is deposited the free metal from the solution. Upon this cathode plate is also deposited all of the amalgam metal which forms within the mixture and which, owing to the circulation of the pulped ore, may come into contact with the copper plate.

In order to aid in the chemical action a strong current of compressed air is admitted into the pulped mass as it is forced outward between the two electrodes by paddles upon the revolving disks. This current of air furnishes free oxygen to the solution, as well as assisting greatly in the agitation. In making a complete clean-up of the whole series of tandem pans it is not necessary to interfere with the continuous operation of the mill, since by the use of a bridging launder, which carries the pulp past the pan being cleaned, five of the pans may be constantly in operation. After the ore relieved of its precious metal burden leaves the last of the series of the electro-cyanide pans it is conducted by means of gravity through a launder to the settler or amalgam trap, where the pulp is slightly agitated, so that the particles of heavy amalgam, which have been carried in suspension throughout the entire train of tanks, may here have an opportunity of settling. From the upper part of this tank the waste pulp flows through a launder to the settling tanks from the base of which it is drawn off and allowed to run outside of the mill as waste product.

As the result of his work the inventor says he has found in practice that he is "able to extract from gold ores, silver ores, and gold and silver ores, ranging in values from 4 oz. to 120 oz. of silver per ton and in gold from 1/5 of an oz. to 1¼ oz. per ton. He has extracted and saved from 60 per cent to 90 per cent of the silver values and from 80 per cent to 97.5 per cent of the gold values in the ores, with a total loss of cyanide, including that portion destroyed by chemical action on impurities in the ores and that portion which remains in solution in the moisture of the settled tailings, varying from 0.55 of a pound for ordinary ores to 7.2 lb. for the high-grade refractory silver ores for each ton of ore treated." (940,821, Nov. 23, 1909.)

Copper.

Separation of Copper and Nickel.—The object of a patent of Dr. H. L. Wells is the direct extraction of copper and nickel from a rich matte. The matte containing nickel and copper sulphide is subjected to the action of a heated hydrochloric acid solution. By agitating a matte containing in the neighborhood of 40 per cent each of nickel and copper, with the amount of hydrochloric acid solution required by calculation to convert the nickel into nickel chloride and heated to about 180° Fahr., a large portion of the nickel contained in the matte will be removed in two or three hours. At the expiration of that time the heated hydrochloric acid solution has been converted into a nickeliferous solution containing some unconverted or free hydrochloric acid and the matte into a cupriferous residue containing some nickel. For the conversion of all the hydrochloric acid into nickel chloride, the inventor treats the nickeliferous solution so derived with matte, either fresh or its solid derivatives until all the free acid has been converted into nickel chloride. Further, for the extraction of all the nickel from the cupriferous solid residue, he treats the same with heated hydrochloric acid solution, either fresh or its liquid derivatives, until all of the nickel in the initial charge of matte has been extracted. The solid and liquid derivatives just referred to are intermediate products obtained in the progress of the process and consist, on the one hand, of matte from which the nickel has been partially extracted, and on the other hand, liquid which has been partially exhausted of its free acid.

As the strength of the solution in free acid determines its rapidity of action, and as the richness of the solid residue in nickel determines its rapidity of action, it follows that the most advantageous results can be secured by simultaneously treating two or more charges consisting of matte and its progressively exhausted derivatives with two or more given amounts of hydrochloric acid solution and its progressively exhausted liquid derivatives. The progressive feature of the process is summarized by the statement that the matte is treated successively with three or more solutions, the first of which it finishes and the last of which is fresh acid which finishes it; while at the same time, the liquid starting as fresh acid acts upon three or more solids in the other direction, meeting the fresh matte at the last step and being finished by it. The end products are a nickel chloride solution, on the one hand, in which there is no free acid or practically none, and, on the other hand, a cupriferous residue in which there is no nickel or practically none. The nickel chloride is treated for nickel and hydrochloric acid, which may used again for the treatment of matte. One of two processes, described for this purpose, is as follows: When the nickel chloride solution is evaporated to dryness and the residual solid nickel chloride is heated to a temperature approaching low redness in an atmosphere containing hydrogen, for example, in water-gas, the nickel chloride is changed to metallic nickel, which is left in a pulverulent condition, while hydrochloric acid goes off and may be absorbed by water. (940,292, Nov. 16, 1909.)

Graphite.

Graphite Electrodes.—Mr. A. M. Williamson patents a process for reducing the porosity and increasing the electrical conductivity of artificial graphite, electrodes, etc., made in the electric furnace. The patent is assigned to the International Acheson Graphite Company. These results are accomplished, without introducing into the completed article any extraneous material by impregnating the articles to be graphitized with a material which is itself capable of transformation into graphite, or which yields a residue capable of such transformation. The carbon electrodes or other articles, after having been molded and baked to drive off the volatile matter, are impregnated with coal-tar pitch, coal tar or molasses, etc. By the use of vacuum or pressure the impregnation may be improved. (935,180, Sept. 28, 1909.)

Reduction of Losses in Gold Recovery.

The following is a description of the Pierce gold separator and amalgamator, which has proven very successful during the past few years in various mills in Colorado, Idaho and elsewhere in decreasing the loss of gold. We will first describe the application of the Pierce machine to placer mining.

In the flume, or at the end of it, is set a section of flume, and in its bottom are placed one or more sets of V-shaped grizzleys, the bars of which are at a slight angle from the flow of the water so that the fine gold, sand and gravel is gradually brought to the openings, and passes through them into the grizzley box, supported by rods underneath the grizzley and flume. Its bottom slants downward with the flow of the water, and at the lower end there is a gate that can be regulated so as to take from the flume only as much water as is necessary to

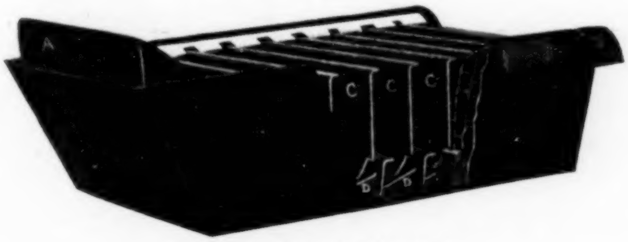


FIG. 1.—PIERCE AMALGAMATOR.

carry or move the gold, sand and gravel that pass through the grizzleys.

The gold, sand and gravel are then taken to the screen boxes, where the coarse gold and gravel are separated from the fine gold and sand, the latter passing through the screens. These are adjusted so that the end of the screen that the gravel passes over is higher than where it comes on the screen. Underneath the screen is a gate which is adjusted so as to take only the amount of water and sand that is required for the amalgamating boxes and riffles. Thus the water is kept over the screens and expels the air from underneath it, and the flow of the water carries the fine gravel and coarse gold over it. There is, therefore, no tendency to clog the meshes of the screen.

The fine gold and sand passing through the screen are then run through the amalgamated copper riffles. The riffle box (Fig. 1), made of iron, is set at an angle of from 2 in. or 4 in. to 1 ft., according to the material desired to be run through.

The lower riffles *D* are bent something like the letter *Z*. At the top the copper is bent back with a flow of the water and forms an air space, the bottom or *L* of the riffles is turned up at each end and brazed, so as to hold quicksilver in the bottom of each riffle.

The upper riffles *C*, which are made of wood or copper, are held in place by their holders which set on top of the holders holding the under riffles, and are placed above and extending down between the top of the lower riffles, the tops of which are bent back with the flow of water so as to give them strength, while the bottom is bent toward the flow of the water and so constructed as to hold the quicksilver in the bend, or *L*.

All gold, sand and water is then passed through the riffle boxes underneath the upper riffles *C*, and over the under riffles *D*. As it passes into the riffle box at *A* it fills it to the top of the first upper riffle, and then passes under it, into the first lower riffle and then up between the first and second upper riffles and to the top of them (where it looks like muddy water boiling), then passes down between the next lower riffles, and then up between the second and third upper riffles, and so on between all the riffles to the lower end of the box. In this zigzag way the gold adheres to the riffles, also sinking in the quicksilver, and the sand and water are thrown out of it at *B*.

The water passing down between the lower riffles throws the black sand out and keeps it agitated, and by keeping it in the flow of the water the fine or "flour" gold is swept against the amalgamated coppers or riffles so many times that it is impossible for it to escape.

The coarse gold as it passes over the bodies of quicksilver exposed in the bottom of each of the upper and lower riffles, though it be tarnished, will readily sink into it (as the specific gravity of gold is 19.4 while that of quicksilver is 13.6) thereby saving all of the gold which passes over the ordinary riffles and mill plates.

The coarse gold and fine gravel that has passed over the screen is then run over iron riffles placed in an iron box. The gold is caught in the quicksilver held in the riffles.

If there are values contained in the black sand it can be concentrated as in mills. By this machine placer mining is reduced to a milling proposition, as the sands are separated, and then the gold is amalgamated in the riffles as in mills, and are ready for the concentrator to save the black sands when they contain values.

In cold countries, there is placed underneath the riffle box a flat-top heating tank to hold hot water or steam for the purpose of warming the mercury and water.

In placers where there is clay the machine is set at the head of the flume, with openings in the grizzleys large enough to let all nuggets through so as to get them out of the flume and separated from the clay, to prevent them from being carried out of the flume by it, and they are then treated similarly to that described above.

The same machine may also be used for dredges, where it is set in a flume over the boat, and the separation is made by the grizzleys and screens, thus doing away with the revolving screens.

For the use in mills, the riffles are made the same as those in the placer machine, but smaller, occupying only from 2 sq. ft. to 8 sq. ft. of space, and have from 11 ft. to 14 ft. of amalgamating surface in length. They are made to handle any number of tons crushed in a battery or a mill, and are suitable for any mill, as there is no splash required as for plates. They are set below the mill in place of plates.

These riffles will catch the fine or "flour" gold that passes over plates and concentrators in the slimes; also the heavy tarnished or "rusty" gold that passes over plates which will not amalgamate, but is held in the quicksilver in the riffles.

The riffles can also be used to great advantage in cyanide mills by running the pump through them and saving the free gold before it goes to the tanks. After the tarnished gold has

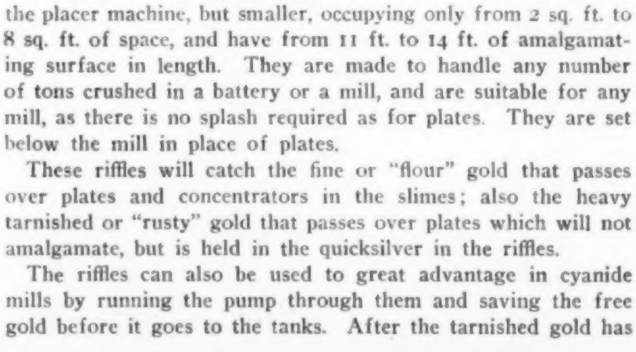


FIG. 2.—AMALGAMATOR AT WORK.

been freed in the tanks by cyanide or other chemicals, it is passed through other sets of riffles so as to amalgamate the gold freed, thus saving much of the chemicals by not dissolving the gold and considerable tankage capacity. Or the riffles can be set below the tanks so as to pass all of the pulp through them, thus catching any gold escaping by not being dissolved.

This machine is being built under patent No. 560,750 by Mr. L. S. Pierce, 1650 Champa Street, Denver, Col., and is in successful use in various Western States.

Hot Blast Stove.

The adjoining illustrations show the Amsler improved hot-blast stove, which is of the three-phase central-combustion chamber type, and is an improvement on the original Massicks & Crooks stove, an English invention. The English design did not find any general acceptance by the American furnace people, as it was deficient in one very vital particular, and that is the matter of providing for expansion and contraction. A hot-blast stove by its nature is constantly either being heated or is being cooled, and the expansion and contraction of the masonry is a very considerable amount in a wall 75 ft. to 100 ft. high. The English design provided that all the masonry be bonded together, and the dome was provided with flues through it longitudinally, connecting the outer or third pass with the chimney.

This design was improved upon by the American agents, Messrs. McClure & Amsler. The improvements consist mainly in separating the three cylindrical vertical walls that form the passes and using a separate crown on the intermediate and the outer walls, the space between being used to connect the last pass with the chimney. This overcame the principal troubles of breaking and crumbling brickwork on account of the uneven expansion and contraction, and it is in this shape that the stove

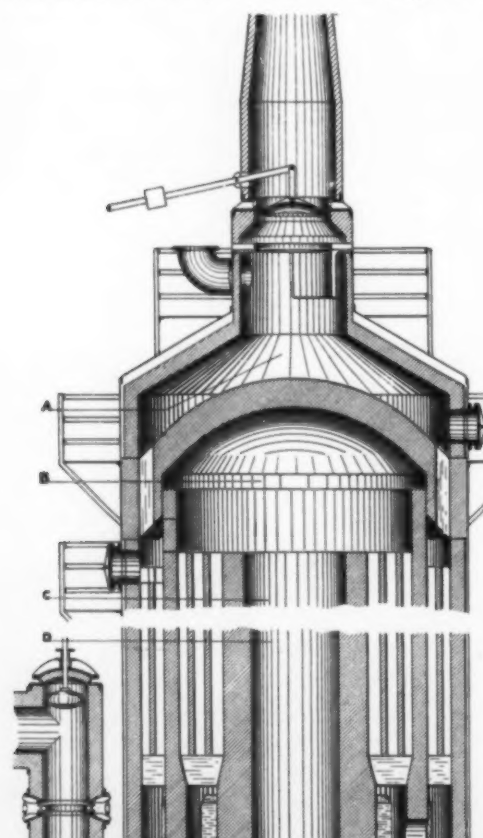


FIG. 1.—VERTICAL SECTION OF HOT-BLAST STOVE.

is being used at present, and finds acceptance in all important installations. The United States Steel Corporation have adopted it and use no other, which bears testimony as to its economy and length of life.

The Amsler improved hot-blast stove is shown in Fig. 1 in vertical section and in Fig. 2 in horizontal section. This design is a further refinement of the original and present stove of this type. It consists of the usual steel air-tight shell lined with firebrick, and provided with the customary cold blast, and gas inlets, and hot blast and chimney outlets, cleaning doors, etc.

The masonry is arranged in three vertical cylindrical walls entirely independent of each other. The two inner ones are open at the top, but the other one is provided with a double dome with vertical flues connecting the outer pass with the space between the domes, and which communicates with the chimney. The intermediate wall is extended up to make a slip joint with a recess provided in the lower dome. The checker work in the passes is built independently of the walls, but is very substan-

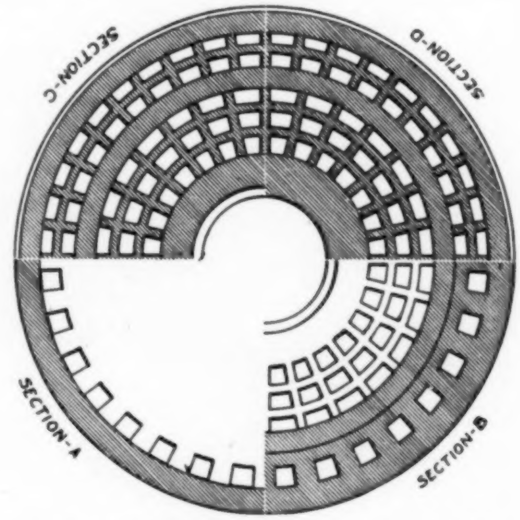


FIG. 2.—HORIZONTAL SECTION OF HOT-BLAST STOVE.

tially bound together. This construction allows of several important improvements. The intermediate wall, having no weight but its own to carry, is made lighter and permits of increased heating surface per stove. The thrust of the lower dome is taken on the plate work and is not transmitted through a checker-work slip joint as in the previous design, and prevents the crumbling of the brick at this point. Another very important feature is that it is possible to use standard 9-in. brick shapes in the stove to a greater extent than heretofore, which has an important bearing on the cost.

There are provided at the base of the stove in the space where the second and the third pass communicate radial walls which extend up to the bottom of the checker work. These prevent the third pass from forming hot flues and producing the trouble known as "hot sides," by equally distributing the gases from the second pass to the third.

Another detail of the improvements is the cold-blast inlet. This is directly under the chimney valve and is so arranged that the entering air strikes a cast-iron baffle plate at a tangent. This takes up the force of the blast and prevents erosion of the masonry.

There are at present three of these stoves, 18 ft. x 75 ft., successfully operating a furnace, 17 ft. x 75 ft., at the Jackson Iron & Steel Company, of Jackson, Ohio. This plant has been in operation for two years and is giving entire satisfaction. A similar plant is under erection for the Bessie Ferro-Silicon Company, of New Straitsville, Ohio.

Dr. Walter O. Amsler, of Pittsburgh, Pa., the designer and patentee of this stove, is a son of the late Carl Amsler, one of the pioneer metallurgical engineers of the steel industries.

Copper Production in 1908.—According to statistical figures of the Geological Survey the production of copper in the Central States, which had a value of $43,553,466 in 1907, amounted to only $29,473,844 in 1908, a decrease of more than 32 per cent. These figures are taken from a report of B. S. Butler and C. E. Siebenthal, which covers Arkansas, Illinois, Iowa, Kansas, Kentucky, Michigan, Oklahoma and Wisconsin.

Production of Gold and Silver in the United States in 1908.

The U. S. Geological Survey and the Bureau of the Mint, acting in co-operation in the examination and analysis of reports for private refineries and records of Federal mints and assay offices, have determined the finished product from domestic mines in 1908 to have been as given below.

The product of gold was 4,574,340 fine ounces, valued at $94,560,000, and the production of silver was 52,440,800 fine ounces, with the commercial value (at the average price of silver for the year) of $28,050,600.

As compared with the figures for 1907 the above shows an increase in the gold product of $4,124,300, and a decrease in in the silver product of 4,073,900 fine ounces. Of the 23 States and Territories producing gold 9 show an increase of production, while 14 show a decrease. Of the 26 States and Territories producing silver, 13 show an increase and 13 a decrease.

Nickel and Cobalt.

From a report by FRANK L. HESS, of the United States Geological Survey (advance chapter from Mineral Resources of the United States for 1908) we take the following summary:

Nickel and cobalt are not produced in large quantities in the United States from domestic ores, the domestic output of nickel in 1908 coming from only two or three places and that of cobalt from only one. Both metals are produced by a lead company, at Fredericktown, Mo., and some nickel ore was shipped from Bunkerville, Nev. Other nickel deposits are known in various parts of the country, but no work of importance was done on them during 1908.

Some nickel salts were made at a New Jersey refinery from electrolytic solutions obtained in the refining of copper. "In copper refining by electrolysis nickel contained in the raw copper anodes goes into solution in the electrolyte, and unless the solutions are changed before the amount of nickel reaches 1 per cent of the solution, nickel is deposited with the copper. It is said that this causes the copper to lose some of its toughness. Before this factor in electrolytic refining was found to be serious it was impossible to make electrolytic copper equal to the best Lake Superior brands, but the refiners say that since the discovery they can make electrolytic copper equal to any other, and even superior to some in electric conductivity."

Some information is given on Monel metal, a copper-nickel alloy, about which an exhaustive article by Mr. D. H. Browne was published in our March, 1909, issue, page 114.

Cobalt occurs at many places in the United States, but all of the 1908 output came from Fredericktown, Mo., where it is produced in connection with nickel and copper from concentrates obtained in mining for lead.

The principal present uses of cobalt are in making glass and pottery. Cobalt oxide imparts a beautiful blue color to glass. Some salts of cobalt change in color on absorbing water, being blue when dry, but pink when damp. A familiar hygrometer making use of this property is a doll whose dress is blue in dry weather and pink in damp weather.

The supply of nickel for the United States comes almost wholly from the deposits at Sudbury, Ont., Canada. In 1908 the imports for consumption had a total value of $2,497,585; in 1907 the value was $2,243,026. The United States refines much more nickel than it can use, so that, though not a producer, it is a large exporter. The exports in 1908 were 9,770,248 lb., valued at $3,297,988, against 8,772,578 lb., valued at $2,845,663 in 1907.

Large quantities of cobalt minerals are contained in the silver ore at Cobalt, Ont., and the greater part of the cobalt used in the United States comes from that locality. The imports for consumption in 1908 were 219,098 lb., valued at $17,077.

A Fly-Wheel Repair in the Wilderness.

The largest fly-wheel repair ever attempted by means of the thermit process was accomplished some time ago at Sylva, N. C., for the Consolidated Nickel Company, under conditions which offered the greatest difficulties.

Sylva is a little town in the wilderness offering absolutely no facilities for a repair job of any magnitude, and the difficulty of handling a fly-wheel segment 24 ft. in diameter and weighing approximately 10 tons can be imagined.

The wheel proper consisted of a combination of two pulleys mounted side by side on the same shaft. Each of these pulleys

FIG. 1.—VIEW OF FLYWHEEL.

was made in two parts which were shipped on flat cars to Sylva. One of these parts had to be removed from the car, leveled up on the ground and welded in three places by the thermit process. There were two fractures on one of the spokes and a fracture directly across the rim, as shown in the illustrations.

All materials for the work were shipped from New York, and engineers of the Goldschmidt Thermit Company were sent to Sylva to superintend the operation. The welding proper would have been a difficult operation, even under favorable conditions, while the hardships encountered due to the poor

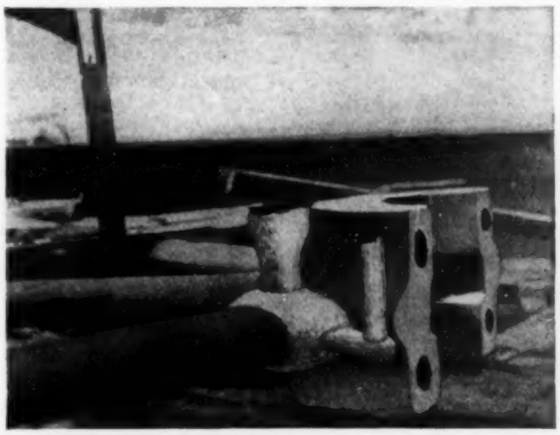


FIG. 2.—FINISHED WELD OF SPOKE NEAR HUB.

facilities for handling the wheel and the class of labor available added tremendously to the difficulties to be overcome.

With the materials on the ground, the first thought was to unload the fly-wheel from the flat car and place it in a suitable position for welding. This was anything but easy to accomplish as the piece weighed 10 tons, while the hoist provided was

of only about 2-ton capacity. At the expenditure of much time and trouble, however, the wheel was finally placed on the ground and the work of lining it up started. Right here more trouble was experienced owing to the fact that a very heavy rain fell during the day and so softened the ground that the fly-wheel would sink into the mud and it was practically impossible to jack it up. Jacks placed underneath it would simply sink out of sight. Eventually, however, it was blocked up and aligned up properly, but it was found that owing to its very great weight, it was slowly sinking, and it was necessary to build a platform on which to set the wheel before it could be permanently lined up ready for welding. A temporary roof was also constructed over it. An entire day was consumed in unloading the wheel and lining it up for welding. The next day, however, a rainstorm came up which softened the ground and necessitated aligning the wheel all over again, and the operation was not finished until the day following.

The repair of the fracture near the hub was made first, an opening of 2 in. being provided at the fracture, leaving just sufficient metal on the edges of the spoke to assist in aligning it. Provision was made for a collar 1½ in. in thickness at the center and 8 in. wide for which a welding portion was required consisting of 250 lb. of thermit, 62½ lb. of punchings, 5 lb. of ferrosilicon (80 per cent Si) and 2½ lb. of pure manganese.

In order to make these welds it was, of course, necessary to obtain compressed air, and this was done by running a pipe line a distance of about 400 ft. to a tannery in the village which boasted an air compressor, although when the original plans had been made for doing the work, it was figured that it would be necesary to obtain compressed air from one of the locomotives of the railroad.

Before pouring the thermit steel the adjacent spokes and hub were thoroughly heated to avoid too sudden cooling at the weld by conduction. Furthermore, as soon as possible after the pour a fire was built around the hub and spokes on both sides of the mold box to further assist in the slow cooling of the weld. This cooling operation was watched very carefully and required about 30 hours. The second weld was not attempted

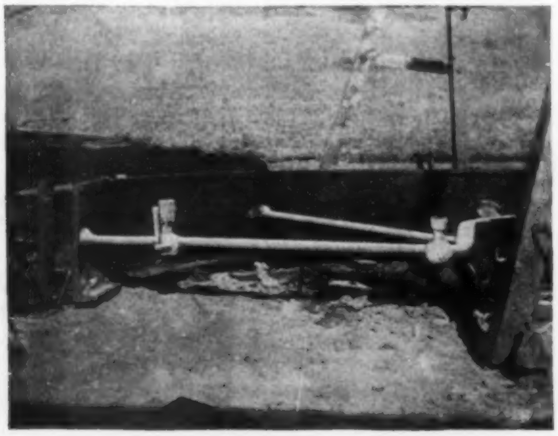


FIG. 3.—TWO WELDS OF SPOKE.

until the first one had cooled thoroughly and was found to be in good condition.

The method of procedure in making the second weld was exactly the same as in the case of the first, as was also the size and composition of the welding portion, but owing to the fact that the weld could not contract freely, it was necessary to take even greater precautions in preheating and expanding the adjacent rim and spokes than was done in the first operation. Great care was also exercised in the annealing and upon the removal of the molds both welds were found to be perfect.

When the second weld was perfectly cold, preparations were made to weld the rim, and here further difficulities arose owing to the fact that it was necessary to change the position of the wheel and raise it up on its rim and revolve it until the fracture was on the ground. For this purpose a huge horse 20 ft. high, constructed of oak timbers, had first to be made, and this, together with all the tackle that it was possible to accumulate and with the aid of all the men in the vicinity, enabled the wheel to be lifted and revolved into position. An idea of the difficulty of this operation can be had from the illustrations and the fact that three days were required to accomplish it.

Having lined up the broken piece of the rim and fastened it in position by means of wrought-iron straps, which had been provided, the work of welding was carried on in the usual way. Provision was made for a thermit steel collar 6 in. wide

FIG. 4.—WELD ACROSS THE RIM.

and ¾ in. thick on the face of the rim and of the same width but 1¼ in. thick on the inside of the rim.

Owing to the fact that one of the spokes came directly out of the center of the wheel, it was deemed advisable to have a riser at that point, as the contraction there would be much greater, due to the heavy section of the spoke. Pouring gates and heating gates were provided at each edge of the rim, the pouring gates leading to a basin into which the crucible was tapped. The welding portion in this case consisted of 500 lb. of thermit, 125 lb. of punchings, 10 lb. of ferrosilicon and 5 lb. of pure manganese.

The melting out of the wax and proper preheating of this section required about five hours, using two preheaters, one on each side, and the pour consequently was not made until about 9:30 in the evening.

The same precautions were taken as regards preheating and provision for slow cooling and contraction as with the other welds, but about midnight a violent storm arose which continued until noon of the following day, and as it was practically impossible to build a roof over the wheel, it was subjected to this downpour of rain. The result was that the next morning a crack was found running longitudinally through the piece which had been welded on, running toward the thermit weld. This crack, however, as it ran lengthwise with the band of the wheel and not across it, did not materially affect the strength of the weld, and it was found to be practicable to repair it satisfactorily by putting on a patch. This was accordingly done, and the wheel returned to its owners.

An idea of the remote location of the town and the wretched facilities for doing work there can be gained from the fact that gasoline had to be obtained 50 miles away and all material had to be taken to the grocery store to be weighed, it being impossible to obtain a pair of scales.

Relation on the Character of Coals to the Prevention of Smoke.

An interesting paper on this subject was presented at the recent Syracuse meeting of the International Association for the

Prevention of Smoke by Mr. D. T. RANDALL, engineer in charge of the fuel engineering department of the Arthur D. Little Laboratories of Applied Chemistry in Boston.

The semi-bituminous and bituminous coals are the most extensively used of all the fuels which are available for generating steam. Containing as they do a considerable quantity of volatile matter which is given off when the coals are heated in the furnace, it is difficult to burn them under boilers so as to secure perfect combustion and freedom from smoke. Specially designed furnaces and careful operation are required to get good results.

The difference in the character of coals is only partly shown by the proximate analyses which are commonly used, but to one familiar with coals these analyses indicate in a general way the leading characteristics of the coals.

To show the difference in fuels the following table has been prepared:

TABLE I.

Analyses of Fuels as Delivered and Used.

	Coke.	Anthracite Pea Coal.	Pocahontas Coal.	Pittsburgh Coal.	Indiana Coal.
Moisture	4.67	4.75	1.12	2.48	9.62
Volatile matter...	2.82	2.90	17.24	38.74	36.14
Fixed carbon.....	82.61	77.15	74.84	49.18	41.22
Ash	9.90	15.20	6.80	9.60	13.02
	100.00	100.00	100.00	100.00	100.00
Sulphur	....	0.80	0.71	1.85	4.43
B. t. u..........	12,206	11,886	14,530	13,172	11,122

It will be noted that coals vary both in their composition and in their heating values (B.t.u.), and in consequence they are more or less valuable as fuel, depending on these variations.

Other things being equal, a fuel high in fixed carbon is more easily burned in a common furnace without loss of heat and without smoke than those of lower percentages. Coke and anthracite coals are examples of this class of fuels.

The percentage of moisture is not of great importance except in cases in which the coal is naturally high in moisture, or in which the coal is very wet as a result of washing or exposure to storms. Moisture in small percentages seems to aid combustion, but in larger amounts it retards the ignition of the gases and lowers the furnace temperature. It may or it may not increase the smoke, depending on the character of the fuel.

The percentage of ash, and especially the character of the ash, is of importance in connection with the smoke problem. Ash which is fusible and runs down onto the grate bars may cause smoke by shutting off the flow of air through the fuel, and by increasing the poking which is necessary to keep the grates free. Coals which clinker badly require more attention from the firemen, and poking the fire is a common cause of smoke.

There is a great difference in the behavior of the same coals when burned under different furnace conditions, and in different furnaces. Some grates and stokers are adapted to handle coals which are burned with great difficulty on other equipment.

The rate of burning per square foot of grate is often the deciding factor as to whether a given coal may be used or not. This is principally due to the higher temperatures which are obtained with high rates of combustion, and its effect on the fusible portion of the ash of the coal. Investigations are now being made to determine the characteristics of the ash of representative coals as related to the clinker formed at various temperatures.

So far as smoke is concerned, the volatile matter is of the greatest importance. The quantity of volatile matter is not a true measure of the difficulty of burning a coal, but to one familiar with the various coal fields it is of great assistance in choosing a suitable coal or in designing a furnace suited to the given coal.

Investigations relating to the nature of volatile matter in representative coals have been carried on at the Government Fuel Testing Plant, at the University of Ohio and at the University of Illinois.

The results show that the differences in the gases given off from coals may be due to the composition of the coal and to the temperatures to which the coal is subjected when placed in the furnace. The higher temperatures tend to distill the volatile matter more rapidly and drive off the heavy hydrocarbon in forms which are difficult to burn without smoke.

TABLE II.

Absolute Quantities of Smoking Products in Ten Minutes' Heating at Different Temperatures.*

Coal.	Temperature, Degs. C. Furnace.	Coal.	Smoking Products. Tar, Per Cent.	C_6H_6—c.c.
3 Connellsville	600	441	4.9	61
1 Ziegler, Ill.......	600	440	6.8	51
3 Connellsville	700	562	11.0	145
1 Ziegler	700	545	7.8	24
16 Pocahontas	700	599	4.2	138

*See paper by Porter & Ovitz in *Journal* of American Chemical Society, Vol. XXX.

The above table gives some idea of the complicated relation between the temperature of the coals in the furnace and the compositions of the various gases to be burned. Investigations of this character are necessary to determine the characteristics of coals from each of the representative beds.

The combustion of coke or other fuels high in fixed carbon is comparatively simple. The greater portion of the fuel is burned on the grate; the remainder, in the form of gas, burns at a short distance above the bed of fuel. This may readily be observed on a fire of anthracite coal, in which there is only a small percentage of volatile matter.

In burning bituminous coals, however, the difficulties are much greater, and for the reasons given above. The volatile matter from some coals is set free more readily than from others, and with some coals the nature of the volatile matter given off is such as to make it very difficult to secure complete combustion. Smoke is an indication of incomplete combustion, and the problem of reducing the amount of smoke is important, not only from the standpoint of the smoke inspector, but also because of the losses in combustible gases, such as carbon monoxide (CO) and hydrogen, which escape with the smoke.

TABLE III.

Showing Relation of Smoke to CO in Flue Gases.*

Average per cent of black smoke	0	7.1	15.5	24.7	34.7	43.1	52.9
Average per cent CO in flue gases.............	0.05	0.11	0.11	0.14	0.21	0.33	0.35
Number of tests averaged	37	18	56	51	36	17	4

*See U. S. Geological Survey Bulletin 325, pages 101 and 167.

Experiments by several investigators have shown that whenever smoke is given off there is also a considerable quantity of carbon monoxide gas and that, as a rule, this gas is accompanied by small percentages of hydrogen and hydrocarbon compounds. The losses due to these combustible gases, which are found in connection with a smoky stack, may vary between 1 per cent and 10 per cent of the fuel.

TABLE IV.

Showing Relation Between CO in Flue Gases and Other Combustible Gases.†

Boiler furnace.....	Smoky CO_2	CO	CH_4	H_2	Clear CO_2	CO	CH_4	H_2
Hand fired........	10.95	3.00	0.70	3.23	8.15	0.0	0.0	0.0

†See Manchester (England) Smoke Abatement Report.

When burning a bituminous coal, the volatile matter must be raised to a high temperature while mixed with a sufficient quantity of air and burned on its passage from the fuel bed to the surfaces of the boiler. In most boiler settings this distance for combustion is very short, and when the gases strike the cold surfaces of the boiler shell or tubes they cool below the temperature at which they will burn rapidly, and, as a result, some escape unburned and others are only partially burned, as shown by the heavy deposits of soot. In properly designed furnaces the space provided for combustion is large for coals giving off high percentages of volatile combustible. Even in such furnaces the firing must be carefully done or at times enough air cannot be supplied to the gas, and smoke results for short periods. In most plants the time required for the gases to pass from the fuel bed to the top of the stack is between 10 and 15 seconds, assuming the velocity to be reasonably uniform at different sections, then, it will be seen, that the gases pass from the fuel bed to a distance of, say, 12 ft. in one second. At the

end of this period there is but little opportunity for the gases to burn. This will make clear the great importance of a sufficient air supply, properly distributed, and an ample space above or back of the grates in which the gases may thoroughly mix and burn within considerably less than one second of time.

That there is a loss due to the volatile gases escaping unburned from an ordinary furnace is shown very clearly by the results of tests made on house-heating boilers. The following table gives figures obtained on two series of tests for the purpose of determining the fuel values of several coals and briquets,* when burned in a house-heating boiler.

TABLE V.

The Relation of Volatile Matter of Smoke and Unconsumed Gases.

Number of tests averaged.	Volatile matter in the combustible.	Ash in dry coal.	Efficiency.	Black smoke.	CO in dry flue gases.
4	18.30	8.00	50.56	18.2	0.44
12	22.71	8.94	56.33	18.0	0.50
7	34.70	11.27	54.11	22.1	0.55
11	38.79	15.02	47.19	30.8	0.62
16	44.46	14.57	47.19	32.9	0.74

The furnace in which the results shown in Table V were obtained is best suited to coke, anthracite or low volatile coals, and, as will be seen, is not adapted for burning bituminous coals with good efficiency, yet many furnaces having practically the same features, such as a grate surrounded by heating surface and a small combustion chamber, are used in power plants for burning high-volatile coals.

Even with furnaces of improved design it is difficult to charge the coal by hand-firing and secure smokeless combustion. This is due to the fact that a comparatively large quantity of gas is liberated immediately after firing at the same time the fuel bed has been thickened and the air enters with more difficulty and without being well distributed with respect to the gases rising from the bed. With such a furnace the loss of combustible gases may be reduced to 5 per cent or less, depending on the coal and the operation.

It is because of the advantage in having the coal gradually heated and the gases distilled from it at a low temperature that a mechanical means of feeding the coal to the furnace is usually more successful in the prevention of smoke.

A good furnace should permit the burning of bituminous coal in sufficient quantities without loss of escaping gases or the formation of smoke when the air supply is about 50 per cent in excess of the theoretical amount.

It has been found by experience that to approach this performance the coal must be fed regularly in small quantities, gradually heated, if possible, and the air supply admitted in such a way as to thoroughly mix with the distilled gases. Furthermore, the space for burning the gases should be large and preferably enclosed in firebrick.

A furnace suitable for certain coals may be entirely unsuited to other coals, and it is only after a careful study of all the factors, such as power to be generated, size and kind of boiler to be use, and the coals available, that an engineer can undertake to design a furnace which will be satisfactory and at the same time give good economy under operating conditions.

Tungsten.

On account of the recent depression in the steel industry the demand for tungsten, which is chiefly employed for tool steels, has been less in 1908 than in the preceding year. In 1908 the domestic production of tungsten ore, reduced to an equivalent of ore carrying 60 per cent of tungstic trioxide (WO_3), the ordinary commercial basis in the United States, was 671 short tons, valued at $229,955, as against 1640 tons, valued at $890,048, in 1907. The statistics at present available from foreign countries show a similar decline. These figures are taken from a report by F. L. Hess, of the United States Geological Survey, published in an advance chapter from "Mineral Resources of the United States, Calendar Year 1908." Mr. Hess gives also details of the industry by States, and a partial bibliography.

The most important use of tungsten is for the manufacture of tool steels. There has been a widespread belief that most of the tungsten mined went into armor plate, but it is stated by the Ordnance Bureau of the Navy Department that tungsten is not now, and, so far as known to that bureau, never has been used in the manufacture of armor plate in this country, and it is not known to have been so used in other countries, though it has probably been used in experimental armor plates. One of the most essential properties of armor plate is its ability to resist shock, and this property is not imparted to steel by tungsten. Tungsten salts are used in fireproofing cloth for curtains, draperies, etc.; in weighting silks; in glass making; as a mordant in dyeing, and for other purposes. Tungsten is now also employed for the tungsten-filament lamp, the latest and most efficient incandescent lamp in commercial use.

Seamless Gasoline Tanks.

The cold-drawn seamless steel tank has solved the problem to find a high-pressure tank, free from danger, for gasoline or like substances. Since commercial gasoline contains always some acid, the steel tank must be provided with a lining which prevents corrosion. Zinc would be attacked by the acid, but tin is not.

The accompanying cut is an outside view of a cold-drawn seamless steel tank, tinned with pure block tin and tested to a hydrostatic pressure of 300 lb. per square inch, as placed on the market by Messrs. Janney, Steinmetz & Company, Philadelphia.

Notes.

An Aluminium Agreement.—The London *Electrical Review* states that the principal producers of aluminium have now arrived at an understanding only to proceed with sales for deliveries until the end of next March. The makers include the Neuhausen Aluminium Industry Company, the French works, with the exception of a small factory, the American works, and, it is said, the British Aluminium Company. It is believed in interested circles that the arrangement represents the preliminary step in the direction of reconstituting the international syndicate.

Thermit Process.—The British Corporation for the Survey and Registration of Shipping of Glasgow, after exhaustive tests, has sanctioned the use of the thermit process for repairs to fractured sternposts, lower portions of rudder frames and damages of a similar character.

Illuminating Gas.—The New York Section of the Society of Chemical Industry held a meeting on Nov. 19 at the Chemists' Club in New York City. The program was a symposium on illuminating gas by Dr. A. H. Elliott, Dr. E. G. Love, C. H. Stone and E. C. Uhlig.

Berlin Industrial Fair.—The Board of Trade of Berlin, N. H., has arranged a fair from Nov. 30 to Dec. 11 in order to endeavor to locate some new live industry in the city, and to advertise the city in general for industrial purposes. Berlin is already the seat of the Burgess Sulphite Fibre Company.

Canadian International Acheson Graphite Plant.—Another very substantial and commodious building is to be added to the Niagara Falls, Ont., branch works of the International Acheson Graphite Company. The structure is to be 50 ft. wide by 105 ft. long. The facilities afforded by this addition will make the Canadian works of the Graphite company quite complete in its ability to care for a rapidly growing trade, made so by Canada's industrial growth. The building will contain a new grinding plant, in which the lubricating, electrotype

*See U. S. Geological Survey Bulletin No. 366.

and other grades of powdered graphite will be prepared for market. It will also contain a stockroom for package goods, such as graphited greases, powders, etc., while a new shipping-room will make it most convenient for promptly filling orders.

Manganese Peroxide Anodes.—In the Lond. *Elec Eng'ing* of Oct. 14 we notice a recent British patent of the Siemens Brothers Company (605, Oct. 7, 1909) for anodes suitable for the electrolysis of zinc sulphate, sodium chloride and other solutions containing free acid, where it is important that the anode shall not be chemically attacked. According to this invention, the anode is formed of a plate of manganese peroxide produced by heating manganese nitrate in a mold. The plate is soaked in paraffin to prevent absorption of the electrolyte, and the end is coated with lead peroxide to provide a good contact.

The **American Blower Company** of Detroit, Mich., have sent us their new illustrated catalog No. 250 on "A B C" blowers for cupolas, forges, melting and heating furnaces, forced drafts, pneumatic tube systems and all other appliances where a strong, steady air pressure is required. Besides well-illustrated, concise descriptions of the latest types of their well-known pressure blowers, forge blowers, volume blowers, fan blowers, etc.; tables are given for determining the sizes of the blowers and proportioning the pipes for the same, with other miscellaneous tables of practical usefulness.

Mixing and Kneading Machinery.—A recent illustrated catalog of the Lynn-Superior Company, of Cincinnati, Ohio, describes mixing and blending machinery for paints, ink, pastes and semipastes, powders, blackings, polishes, greases, lubricating compounds, dental preparations, salts, medical compounds, stock powders, soaps and compounds of all kinds. There are 11 pages, each containing an illustration and brief description of a typical machine of this company, with a statement of capacities and dimensions.

Fluxes for Brass and Iron Foundries.—The necessity for using up borings and scrap of previous melts introduces an element of uncertainty into the mix, to overcome which purifiers have to be added. The United States Alloys Company, 1206 American Building, Baltimore, Md., are announcing a "Number One" (strong) and a "Number Two" (milder) flux which cleanse the metal bath of impurities by converting them into a fusible slag, which rises to the surface and is skimmed off. From ¼ per cent to ½ per cent is generally sufficient to eliminate iron, sand, dirt, grease, etc., from brass mixtures, even when present in considerable quantity. The metal may then be strengthened and a sound casting ensured in the usual way by the addition of a little manganese-copper or silicon-copper, or, in the case of iron castings, one of the ferro-alloys. The United States Alloys Company is prepared to furnish various guaranteed alloys and will ship 5-lb. and 10-lb. sample lots of fluxes without charge, express collect, to prospective customers.

Manganese-Silicon-Ferro.—Messrs. Dana & Co., 32 Broadway, New York, have issued a little pamphlet, entitled "Facts for the Expert Steel Maker" on a new manganese silicon-ferro alloy. It can be obtained in several grades. One typical analysis is 24.90 Si, 67.73 Mn, 0.091 P, 0.176 C, 0.012 S. Some of the advantages are the large reduction of the amount of impurities introduced with the ferro-alloy into the steel (especially the low-carbon content), the reduction of the loss of manganese by oxidation; it is non-explosive.

Sarco is the title of a "bulletin of power-plant practice," of which we have received No. 2 (October, 1909). It is issued by the Sarco Fuel Saving & Engineering Company, 90 West Street, New York, who make a specialty of CO_2 recorders, fuel calorimeters, blast-furnace charge recorders, draft gauges, pyrometers, etc. The bulletin contains some interesting articles. One entitled "Misinformation," criticizes some recent erroneous statements on the use of CO_2 recorder, the writer having stated that CO_2 recorder users should not attempt to get too high a CO_2 percentage and that 7 or 8 per cent CO_2 was already uneconomical. While it is true that users of CO_2 recorders frequently attempt to obtain dangerously high values of CO_2, this statement only becomes true when the percentage of CO_2 rises above 13 per cent. The illustrated article by Lewis Sanders on combustion of coal is continued. Then there are some "Don'ts for CO_2 recorder users." We quote a few of them: "Don't think that because you have a recorder in use, it will reduce your coal bills unless you make use of the information given by the daily charts." . . . "Don't try to operate the furnaces with less than 40 per cent excess air indicated by from 10 to 13 per cent CO_2, according to the volatile matter in the coal. You will be forming sufficient CO to counterbalance all the good effects of high CO_2."

Treatment of Timber for Underground Work.—It is estimated that mine operators of this country can save $12,000,000 a year by treating the timber used underground for props and decreasing the annual replacement necessary by decay from one-third of the total amount in use to one-thirteenth of the same amount. We quote Mr. W. F. Sherfesco, who says, in a new bulletin just issued by our active U. S. Forest Service: "The estimated life of an untreated mine prop is approximately three years. With a proper preservative treatment this life may be increased by approximately 10 years, giving a total life for the treated props of 13 years. All of the mine props, both round and square, in use in the United States, contain approximately 500-million cubic feet. About 40 per cent of this quantity, or 200-million cubic feet, can be advantageously treated. If no preservative methods were used the annual replacement of this 40 per cent would amount to one-third of 200 millions, or approximately, 67-million cubic feet of timber. If they were all given a proper preservative treatment the annual replacement would be reduced to one-thirteenth of 200 million, or approximately, 15,300,000 cubic feet. Hence, by a proper preservative treatment of all mine timbers which can be treated advantageously, an annual saving would result of approximately 51,700,000 cubic feet, equivalent to 310,200,000 feet, board measure, or more than half of the present annual cut."

The **Denver Engineering Works Co.** announces the appointment of Walter H. Trask, Jr., as district sales manager at Salt Lake City, to succeed Carroll Helmick, resigned. Mr. Trask is a mechanical engineer, a graduate of the Massachusetts Institute of Technology and has been a salesman at the company's main office in Denver for the past two years.

Mr. **A. H. Reed** has resigned as engineer with the Independent Phosphate Company, Columbia, Tenn., to accept the position of local manager of the Rosiclare Fluorspar & Lead Mines, Rosiclare, Ill.

Messrs. **Pelton & Crane,** of Detroit, Mich., have just issued their 1910 electrical equipment catalog, chiefly for dentists' offices, with descriptions of electric dental furnaces, electric heaters for various purposes, etc.

Mr. **Arba B. Marvin** has opened an office at 950 Commercial National Bank Building, Chicago, Ill., as a solicitor of patents. Mr. Marvin is a graduate of the University of Wisconsin; he has been for a time instructor in electrochemistry at this University, and has made a special study of chemistry, electrochemistry and electrometallurgy. Mr. Marvin studied law at Columbian University, was for two years examiner in the U. S. Patent Office, and for the past five years he was assistant attorney in the patent department of the General Electric Company at Schenectady.

NEW BOOKS.

Richards, Rob. Hallowell. Text-book of ore dressing. 700 pages. Price, $5 net. New York: McGraw-Hill Book Company.

Ruer, Rudolf. The elements of metallography. Authorized

translation by C. H. Matthewson. 342 pages. Price, $3 net. New York: John Wiley & Sons.

Low, Albert Howard. Technical methods of ore analysis. Fourth edition. 361 pages. Price, $3. New York: John Wiley & Sons.

Sellers, J. F. An elementary treatise on qualitative chemical analysis. Second edition, revised. 185 pages. Price, $1. Boston: Ginn.

Steinmetz, C. Proteus. Theoretical elements of electrical engineering. Third edition, revised. 464 pages. Price, $4 net. New York: McGraw-Hill Book Company.

McAllister, Addams Stratton. Alternating-current motors. Third edition, revised and enlarged. 334 pages. Price, $3 net. New York: McGraw-Hill Book Company.

Thomälen, Adolf. A text-book of electrical engineering. Translated from the German by G. W. O. Howe. Second edition. 472 pages. Price, $4.20 net. New York: Longmans, Green & Company.

Low, D. Allan. Applied mechanics; embracing strength and elasticity of materials, theory and design of structures, theory of machines and hydraulics; a text-book for engineering students; with 850 illustrations and 780 exercises. 558 pages. Price, $2.75. New York: Longmans, Green & Company.

Crawshaw, F. D. Metal Spinning. 80 pages, illustrated. Price, 25 cents. Chicago: Popular Mechanics Company.

BOOK REVIEWS.

The Metallurgy of the Common Metals, Gold, Silver, Iron, Copper, Lead, and Zinc. By **Leonard S. Austin,** Professor of Metallurgy and Ore Dressing at the Michigan College of Mines. Second edition, revised and enlarged. 494 pages, 195 illustrations. Price, $4. San Francisco: Mining & Scientific Press.

The first edition of this work was reviewed in our volume VI, page 43. The fact that a second edition has become necessary only two years after the issue of the first edition proves that a book like this was needed.

The second edition has been revised and enlarged in many respects. The subject of thermochemistry, which forms a commendable feature of the book, has been expanded. The description of the cyanide process has been amplified and brought up to date, especially with respect to silver. The metallurgy of zinc has been treated more fully and particular attention given to the principles underlying the smelting of zinc ores. These and other changes and additions have undoubtedly greatly enhanced the usefulness of the work.

* * *

Radiation, Light and Illumination. A series of engineering lectures delivered at Union College. By **Charles Proteus Steinmetz,** A.M., Ph.D. Compiled and edited by Joseph LeRoy Hayden. 305 pages, illustrated. Price, $3 net. New York: McGraw-Hill Book Company.

The distinguished author, who has been aptly called the "Maxwell of alternating-current engineering," deals in this book with a new subject and speaks to a wider public. The work is "intended not merely as a text-book of illuminating engineering, nor as a text-book on the physics of light and radiation, but rather as an exposition, to some extent, from the engineering point of view, of that knowledge of light and radiation which every educated man should possess, the engineer as well as the physician or the user of light." For this reason mathematical formalism is avoided almost throughout the whole book and the phenomena are described in plain language.

There are 13 chapters, dealing with the nature and different forms of radiation, relation of bodies to radiation, physiological effects of radiation, chemical and physical effects of radiation, temperature radiation, luminescence, flames as illuminants, arc lamps and arc lighting, measurement of light and radiation, light flux and distribution, light intensity and illumination, illumination and illuminating engineering, physiological problems of illuminating engineering.

The subject is one with which everyone should be more or less acquainted, and Dr. Steinmetz's exposition of the subject is authoritative and masterful.

* * *

The Calculations of General Chemistry. With definitions, explanations and problems. By **William J. Hale,** Ph.D., assistant professor of chemistry in the University of Michigan. 174 pages. Price, $1 net. New York: D. Van Nostrand Company.

The training of the chemist must be twofold; he must learn to experiment and he must learn to interpret the results of experiments. Such interpretation requires simple mathematical calculations. Dr. Hale says in his preface: "The justification for a book of this character is to be found in the realization that many of the mathematical applications of our fundamental conceptions in chemistry, even upon the most elementary points, remain uncomprehended by students several years advanced in the study of the science." He thinks that it is "absolutely essential that more time be given in the college courses on general chemistry to these mathematical demonstrations. Unless a clear and concise exposition of the methods of calculation is presented in the very first course of college work, the progress of the student is greatly hindered."

Very properly Dr. Hale emphasizes, however, that chemical calculations should be associated, as much as possible, with experimental work. Hence, his book is intended to accompany the laboratory work in general chemistry and to help the student to a better understanding of the many possible conditions that may arise in the course of experimental work. The ideal plan, therefore, should be to associate these problems and their solutions with the actual laboratory practice.

We feel sure the book will be found useful for this purpose. It comprises no more than is presented by the author to students in their first year of chemistry at the university. But he hopes that at least the first portion of the book may have a helpful and profitable bearing upon the instruction of chemistry in high schools.

There are 12 chapters, dealing with units of measurement; density and specific gravity; the effect of pressure upon gases; the effect of temperature upon gases; the combined effect of pressure and temperature upon gases, partial pressures; Avogadro's hypothesis and some of its applications; the law of definite proportions; the derivation of chemical formulas; calculations depending upon chemical equations; normal solutions; combinations between gases by volume; complex equations.

In each chapter the principles are concisely stated and the general methods of calculations explained and illustrated by examples. At the end of each chapter a number of problems are given with answers, but without solutions. There are 275 such problems in the whole book.

* * *

Metallographia applicata a Prodotti Siderurgici. By Ingenieur **Umberto Savoia.** 16mo, XIII and 208 pages, 94 illustrations. Price, 3.50 lire. (Retail price in New York, $1.25.) Milan: Ulrico Hoepli.

An Italian book is almost always well printed, on good paper, and in general a delight to the eye. The publishing house of Hoepli keeps up the reputation of Italy in this respect, but also in most commendable fashion it is publishing selected technical works such as will work wonders in advancing the scientific development of Italian industries. This work on "metallography applied to iron products" is carefully and accurately written (the microphotographs are particularly good), and will aid greatly in promoting the iron and steel industry in Italy, which will be largely electrometallurgical, there can be no doubt.